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Kaleidoscopes and economic models:

when they work, they translate reality
into recognizable images

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In This Issue

How do we learn the truth about an economic variable, such as the price of hogs? One way is to study its history carefully and discover exactly what sort of behavior it has exhibited. Frequently, one finds patterns in its past that prove useful in predicting its future. Another way is to study the historical interrelationships of the variable with a number of others and to rely on economic theory to suggest what sort of relationships might be meaningful. Then if you know (or assume you know) the values of some variables in the interrelated system, you can explain and predict the values of others. These two contrasting and fundamentally different ways of applying economics are illustrated in this issue.

The article by Bessler examines variables one at a time. Bessler used advanced statistical procedures developed during the past two decades, such as adaptive expectations, exponential weighted forecasts, and autoregressive integrated moving average processes. However, his general approach is far older. The Babylonians used it successfully 3,000 years ago to describe the paths of the wandering planets and to forecast eclipses of the sun. Bessler applied the method to 25 time series of agricultural prices and quantities. He found it useful for describing and predicting behavior in about half the cases. This degree of success explains why the method has been used all these years. However, the fact that the method failed in about half the cases explains one reason why science has sought other methods.

The article by Salathe, Price, and Gadson reviews an econometric model ERS used to describe the interrelationships of 360 endogenous variables and to forecast their values by assuming values for 265 exogenous variables. This model, too, builds on the work of many people over the past three decades. Both methods have descriptive uses, and both give very good forecasts of some variables. But, the ERS model grows out of a more recent tradition and has some fundamentally different properties. It reflects the scientific revolution which had roots in the thinking of the ancient Greeks, but which bore fruit mostly during the past three or four centuries. It seeks to go beyond describing appearances and seeks to explain the mechanism behind them. It depends for explanation on empirically significant descriptions of theoretically valid relationships among variables.

While both methods describe and forecast, the latter is capable of doing more. With the aid of economic theory, it can explain why a variable takes on the values it does. And it can go beyond history to estimate what might have happened had historical events been different. Or, we can use the same feature to predict alternative futures. In their article, Salathe and others illustrate this property by assessing the probable consequences for U.S. agriculture of both an increase in the export market for corn and a decrease in U.S. imports of beef.

Clark Edwards

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The Food and Agricultural Policy Simulator

By Larry E. Salathe, J. Michael Price, and Kenneth E. Gadson*

Abstract

This article describes the structure and dynamic properties of the Food and Agricultural Policy Simulator (FAPSIM), an annual econometric model of the U.S. agricultural sector. FAPSIM estimates a simultaneous price-quantity equilibrium solution for a set of individual commodity models developed for beef, pork, dairy, chickens, eggs, turkeys, corn, oats, barley, grain sorghum, wheat, soybeans, and cotton. FAPSIM also endogenously determines farm production expenses, cash receipts, net farm income, Government deficiency and reserve storage payments, consumer price indexes for food products, and farmer participation in Government commodity programs. The model estimates that each 100-million-bushel increase in corn exports increases the price of corn by $0.15 per bushel.

Keywords

Agriculture, crops, econometric model, feed grains, livestock, policy analysis

The agricultural sector model described in this article is the outgrowth of research by numerous individuals over three decades.[1] In the fifties and sixties, researchers in the Economic Research Service (ERS) began developing econometric models for selected commodities (*22*).[2] Such models were generally small (not exceeding 10 equations) and recursive, reflecting the lack of computational capability. It was not until the midsixties that various researchers in ERS urged that resources be devoted to the development of a comprehensive model of the U.S. agricultural sector. The motivation for development of such a model was twofold. First, the model would enhance and support the Agency's intermediate-term economic intelligence and forecasting ability. Second, the model would provide a means for evaluating and quantifying the impacts of alternative legislative proposals and policies on the agricultural sector.

The seventies began with James Matthews as head of the Price Research and Methods Section, ERS. Under his leadership, work began on a model that would reflect major components of the total U.S. agricultural industry. Model development was to proceed in two steps. First, models would be developed for individual commodities or commodity groups. Once a model was operational, it would be linked to other commodity models via common variables.

The first phase of the process built on previous research both within and outside of ERS. This phase began with the development of an econometric model of the soybean industry (*11*). This model underwent several revisions during the seventies (*2*, *15*, *16*). Annual econometric models for the major livestock commodities were also developed in the early and midseventies and updated and revised in the late seventies (*6*, *7*, *8*, *12*, *23*).

Researchers encountered several problems in linking the various models. As a result, the process of linking the various models tended to lag behind that of developing the individual component models. One problem researchers encountered in linking the various models was their difficulty in maintaining commonality in variable definitions across models. Often, they had to reestimate portions of the various commodity models using common variables prior to including them in the linked system. A more serious and difficult problem manifested itself as more models were added to the linked system. As the size of the system grew, the dynamic properties of the linked system became unstable even though the individual commodity models displayed stable characterisitcs.

Despite these problems, the initial version of the linked crops-livestock model, known as the Cross Commodity Forecasting System (CCFS), was made operational in the late

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[1] The authors thank Charlotte Tucker and Jim Tannehill for providing statistical assistance. Numerous other individuals have made invaluable contributions towards the development of FAPSIM. The range of contributions precludes identifying all individuals responsible for the model's development. Unable to provide an exhaustive list of individuals contributing to the model's development, the authors simply wish to gratefully acknowledge the previous research efforts of such individuals.

[2] Italicized numbers in parentheses refer to items in the References listed at the end of this article.

seventies. The CCFS consisted of approximately 160 equations for predicting prices, supplies, utilization, and ending stocks of beef, pork, milk, chickens, turkeys, eggs, corn, oats, barley, grain sorghum, wheat, soybeans, soybean meal, and soybean oil (*19*). Generally, the model's equations were based on annual data prior to 1977.

After ERS's 1979 reorganization, work began on updating the CCFS. Under the direction of Larry Salathe, the entire CCFS was updated in 1980-81. The model was also altered to enhance its policy analysis capability in preparation for the 1981 farm bill. Respecification of numerous equations in the CCFS became necessary because the inclusion of data for the late seventies altered equation parameter signs. Major modifications of the model in preparation for the 1981 farm bill included adding equations to predict: cotton prices, supplies, and utilization; production, utilization, and Government purchases of butter, cheese, nonfat dry milk, fluid milk, frozen milk products, and condensed and evaporated milk; crop yields; consumer food price indexes for major food categories; and Government outlays for deficiency and reserve storage payments and dairy price support operations for major farm commodities. In addition, a new approach for predicting crop acreage response was incorporated into the model.

The new model was named the Food and Agricultural Policy Simulator (FAPSIM) to emphasize its policy analysis capability. However, since it became operational in early 1981, the new model has demonstrated an ability to predict future events with reasonable accuracy. Currently, it contains 360 endogenous and 265 exogenous variables (*18*). Because of the size of the model, an indepth discussion of its structure is deferred to succeeding articles. Our purpose here is to provide an overview and to present a series of validation results. In addition, the model is used to analyze the impacts of fluctuations in corn exports and beef imports on the agricultural sector. These alternative scenarios provide information on the model's stability and on impact multipliers.

Model Overview

Prior to solving for equilibrium commodity prices, production, and utilization (consumption, exports, and stock levels) in any particular year, all the exogenous variables are initialized. A major subcategory of exogenous variables includes Government policy variables such as individual crop loan rates, target prices, national program yields and acreages, and diversion and set-aside rates. Another major subcategory of exogenous variables includes macroeconomic variables such as population, disposable personal income, food processing wage rates, petroleum prices, and the nonfood consumer price index.

The livestock and crop components of the model are solved simultaneously.[3] Livestock slaughter, breeding herd size, and replacement numbers are functions of lagged crop year prices. For example, the number of heifers added to the breeding herd during calendar year 1980 is specified as a function of the price of corn in crop year 1979 (Oct. 1979-Sept. 1980).[4] Crop prices are also affected by livestock prices and livestock numbers. For example, corn feed demand in crop year 1979 is specified as a function of the number of grain-consuming animal units on farms and an index of livestock prices in calendar year 1980.

Farm cash receipts, production expenses, and net farm income are calculated for calendar year 1980 based on crop year prices and production in 1979 and 1980 and on livestock prices and production and the prices of farm inputs in calendar year 1980. The consumer price indexes for food and all items (food and nonfood) are computed by weighting individual consumer price indexes for livestock and crop commodities by their relative importance as determined by the Bureau of Labor Statistics. The consumer price index for all items is endogenously computed and is used as a general deflator in all retail demand equations.

A set of general functional relationships is provided below for each major subsector. These relationships are typical of those contained in the model.

Livestock Subsector

Livestock commodities contained in FAPSIM include beef, pork, dairy, chickens, eggs, and turkeys. Each individual livestock submodel consists of a set of equations used to estimate production (slaughter), market and retail prices, civilian consumption, and ending stocks. In addition to these variables, the dairy submodel also contains a detailed milk processing component.

Supply

Considerable detail is provided on the stock of breeding animals, additions to the breeding stock, slaughter of the breeding stock, and the size of the livestock crop. The identity given below is used to track changes in the stock of breeding animals:

[3] A Gauss-Seidel solution algorithm is used to solve the model's simultaneous system of equations. An indepth discussion of this algorithm may be found in (*4*).

[4] A variety of regression formulations were specified to evaluate the appropriateness of alternative linkages between calendar year livestock and marketing (crop) year crop variables. A comparison of the regression results indicated that models specifying livestock production as a function of lagged crop prices generally had more reasonable parameter values and lower mean square errors than alternative specifications.

$$HERD_t = \lambda HERD_{t-1} + ADD_t - SLTR_t \quad (1)$$

where:

$HERD_t$ = the ending stock of breeding animals on farms in year t,

λ = survival rate,

ADD_t = additions to the breeding herd in year t, and

$SLTR_t$ = slaughter of breeding animals in year t.

Similar accounting identities are employed to track changes in the number of market animals on farms.

Slaughter of breeding animals depends on the profitability of livestock feeding. The number of breeding animals slaughtered is positively related to the stock of breeding animals and negatively related to the ratio of livestock price to feed price. Additions to the breeding herd are a function of the ratio of livestock price to feed price and of the number of animals eligible to enter the breeding herd.

The stock of breeding animals governs the size of the livestock crop. The size of the livestock crop in turn determines future livestock slaughter as well as additions to the breeding herd. Livestock slaughter depends on the ratio of livestock price to feed costs and on the number of market animals on farms. Total production is expressed as a linear function of the number of animals slaughtered. Total supply of livestock equals livestock production plus beginning stocks and imports. Imports are treated as exogenous.

Demand

Civilian consumption of livestock is determined by the identity:

$$CDISAP_t = PROD_t - STOCKS_t + STOCKS_{t-1} + IMPORTS_t - MDISAP_t - EXPORTS_t \quad (2)$$

where

$CDISAP_t$ = civilian consumption in year t,

$PROD_t$ = production in year t,

$STOCKS_t$ = ending stocks in year t,

$MDISAP_t$ = military consumption in year t,

$EXPORTS_t$ = exports in year t, and

$IMPORTS_t$ = imports in year t.

Military consumption and exports are treated as exogenous. Ending stocks are expressed as a function of total supply and the ratio of current to lagged retail price.

Price

The retail price index for each livestock commodity is determined by an econometric relationship expressing the real retail price as a function of own per capita consumption, real per capita disposable income, and the retail prices of competing livestock products. These price-dependent demand equations are homogenous of degree zero in prices and income. Competing livestock prices are included in each demand equation. For example, the retail price index for pork is a function of the retail prices of beef and poultry (chicken and turkey).

Farm and market prices of each livestock commodity are estimated by use of the corresponding retail price index and variables reflecting meat processing and marketing costs. The wage rate in each livestock processing industry and a general fuel price index are used as proxies for changes in meat processing and marketing costs.

Each livestock submodel consists of a simultaneous system of equations and is linked to other livestock models through either production or retail demand. Livestock production and prices in turn affect the crops subsector through the demand for feed.

Crops Subsector

Crop commodities in FAPSIM include corn, oats, barley, grain sorghum, wheat, soybeans, and cotton. Each crop submodel consists of a set of equations used to estimate production, total supply and demand, price, and ending stocks. The soybean submodel also contains a soybean processing component.

Supply

Total supply of each crop is computed as the sum of production, beginning stocks, and imports. Imports are treated as exogenous. Production is determined by multiplying acreage harvested by yield per harvested acre. Both acreage harvested and yield are determined endogenously. Acreage harvested is expressed as a linear function of acreage planted. Yields are expressed as a linear function of acreage planted, acreage set aside and diverted, weather, and the ratio of lagged crop price to the price of fertilizer. Time is included to reflect changes in technology, such as hybrid seed, drought-resistant seed varieties, and increases in seeding rates.

A major shortcoming of previous research has been the failure to develop acreage response equations that explicitly predict the level of farmer participation in Government commodity programs. For example, the acreage response equations developed by Houck and Ryan (*10*) contain Government policy variables such as the effective support price and the effective diversion payment rate. These equations can be used to predict total acreage response, but they cannot predict the level of Government program participation.

The acreage response relationships contained in FAPSIM reflect the relative profitability of either participating or not participating in a Government commodity program.[5] The expected net return per acre for a program participant who produces crop *i* is:

$$EPR_i = [(EPP_i*EY_i - VC_i)(1.0 - (SA_i + DIV_i))] + [SR_i*PY_i(1.0 - (SA_i + DIV_i))]\ ALLOC_i + [DR_i*PN_i*PY_i*DIV_i] \quad (3)$$

where:

EPR_i = expected program return per acre for crop *i*,

EPP_i = the maximum of the loan rate and the expected market price,

EY_i = expected yield per acre,

VC_i = variable cost per acre,

SR_i = expected deficiency payment rate (announced target price minus the maximum of the expected market price and loan rate) per acre,

PY_i = national program yield,

SA_i = proportion of each acre required to be set aside,

DIV_i = proportion of each acre required to be diverted,

DR_i = diversion payment rate per bushel,

$ALLOC_i$ = minimum national program allocation factor, and

PN_i = proportion of acreage eligible for diversion payments.

The expected net return per acre for a Government program nonparticipant who produces crop *i* is given by the identity:

$$EMR_i = EMP_i*EY_i - VC_i \quad (4)$$

where:

EMR_i = expected market net return per acre for crop *i*,

EMP_i = expected market price,

VC_i = variable cost per acre, and

EY_i = expected yield per acre.

Central to the development of acreage response equations is the construction of variables that reflect farmers' perceptions of expected prices and yields. There appear to be at least two alternative price mechanisms that farmers might use as the basis for their price expectations. The first is actual market price prior to planting, and the second is the futures market price at harvest. Given the problems in predicting futures market prices, especially in an annual simulation framework, a simple average of monthly crop prices 1-5 months prior to planting is assumed to represent farmers' price expectations.[6] The expected price prior to planting is endogenously determined as a function of the season-average market price in the previous crop year.

Crop yields are also unknown at the time of planting. Again, there appear to be at least two alternative yield estimates that farmers may use as the basis for their planting decisions. First, farmers can base future yield perceptions on past or experienced yield levels. Or, alternatively, they can discount abnormal weather conditions in past years and base their expected yield perceptions on yields realized under "normal weather" conditions. In FAPSIM, expected yields are generated by regressing actual yields on time, which assumes farmers base their expected yield perceptions on "normal weather" yield trends.

The expected net return variables are used to estimate acreage response by participants and nonparticipants. Total acreage in the program (planted plus diverted and set-aside acreage) for crop *i* is expressed as a behavioral relationship of the form:

$$PA_i = f\left[\frac{EPR_i}{CPI}, \frac{EMR_i}{CPI}, \frac{APP_i}{CPI}, NP_i(1.0 - SD_i)\right] \quad (5)$$

[5] The acreage response equations contained in FAPSIM follow from previous research by Robert Bancroft of the University of Vermont, while he was employed by ERS (*1*). The authors wish to thank Dr. Bancroft for his valuable assistance.

[6] The average of monthly crop prices prior to planting is adjusted to reflect the historical movement in crop prices between planting and harvest.

where:

PA_i = program acreage for crop *i*,

APP_i = the average expected net return of competing crops,

NP_i = national program acreage for crop *i*,

SD_i = set-aside plus diversion rate for crop *i*, and

CPI = the all item consumer price index lagged one period,

and where EPR_i and EMR_i are defined as above. Program acreage is positively related to the deflated, expected program return (EPR_i/CPI) because this variable represents the profitability of planting crop *i* and of participating in the Government program. Total program acreage is negatively related to the real, expected, market net return for crop *i* (EMR_i/CPI), as it measures the attractiveness of nonparticipation, and is negatively related to the average real return for competing crops (APP_i/CPI). Because the announced national program acreage and diversion requirements place an upper limit on total program acreage, an expansion in national program acreage or a reduction in set-aside and diversion rates will expand total program acreage.

Total acreage planted to a particular crop by program participants is a function of total program acreage multiplied by program set-aside and diversion rates. Acreage set aside and diverted is calculated endogenously as total program acreage minus acreage planted by participants. The participation rate is endogenously computed as acreage planted by participants divided by the sum of acreage planted by participants and nonparticipants.

Acreage planted to crop *i* by nonparticipants is a function of acreage planted to crop *i* by program participants, acreage set aside and diverted, the real expected net return of competing crops, and the real expected market return for planting crop *i*. Acreage planted in the program, acreage set aside and diverted, and the real, expected, net return of competing crops all represent the desirability of using land for alternative purposes. Thus, acreage planted to crop *i* by nonparticipants is inversely related to each of these variables. Acreage planted by nonparticipants is positively related to the real, expected, market net return.

Demand

Total demand is the sum of export, seed, food, and feed demand. Exports of corn, wheat, soybeans, soybean meal, soybean oil, grain sorghum, and cotton are endogenously determined. Exports are generally expressed as a function of domestic price deflated by the exchange rate, the exchange holdings of major importing countries, and grain and livestock production in major grain importing countries. Per capita food demand for crop *i* is a function of the real price of crop *i*, the real price of competing crops, and real disposable per capita income. The real price of each crop is the farm price deflated by the all-item consumer price index. The farm price is included in these relationships because retail prices for individual crops are not available.

Feed demand for each crop is a function of own crop price and the prices of competing crops, deflated by an index of livestock prices, and a livestock production index. This formulation assumes that livestock producers increase feeding rates when crop prices decline relative to livestock prices. The livestock production index is an average of the number of livestock on farms, weighted to reflect the relative amounts of grain fed to different types of livestock.

Seed demand is a function of acreage planted in the following year, current crop price, and a time trend. The time trend is included to reflect increases in seeding rates per acre. Seed demand is positively related to crop price and acreage planted.

Stocks and Price

A common approach to estimate stock levels is to calculate ending stocks as the residual difference between total supply and total demand. The basic model framework using this approach is:

$$S_t = S(P_{t-1}) \quad (7)$$

$$D_t = D(P_t) \quad (8)$$

$$ST_t = S_t - D_t + ST_{t-1} \quad (9)$$

$$P_t = P(ST_t/D_t) \quad (10)$$

where:

S_t = total supply in period *t*,

D_t = total demand in period *t*,

P_t = price in period *t*, and

ST_t = total ending stocks in period *t*.

Current year price is a function of the ratio of ending stocks to total demand. This is commonly referred to as a "disequilibrium" model stemming from the failure of the price equation (10) to necessarily equate supply and demand. This failure results from the estimation of equation (10) as a

structural, rather than a reduced form, equation. The FAPSIM model uses the alternative framework:

$$S_t = S(P_{t-1}) \quad (7')$$

$$D_t = D(P_t) \quad (8')$$

$$ST_t = ST(P_t) \quad (9')$$

$$P_t = F^{-1}[S(P_{t-1}) + ST_{t-1} - D(P_t) - ST(P_t)] \quad (10')$$

where market price (equation (10′)) is determined by substituting equations (7′) through (9′) into the supply-demand identity and by solving for price. Comparison of equations (10) and (10′) indicates that equation (10) will not necessarily provide a market clearing price consistent with specified demand and supply functions.

Past theoretical research suggests that the demand for commercial stocks consists of two components: (1) a speculative demand and (2) a transactions demand (*14*). Transactions demand for stocks is normally expressed as a function of sales whereas the speculative component is normally expressed as a function of expected price. These two stock demand components suggest that commercial stock levels are a function of own (current) real price and of total crop demand. The level of Government and reserve stocks are also included in the commercial stock equations as they may partially substitute for commercial stock holdings.

Farmer-owned reserve (FOR) and Government stock levels are determined by the use of a set of decision rules. It is assumed that Government and reserve stocks will accumulate up to the point where crop price equals the designated loan rate. If the initial equilibrium price is above the designated reserve release level, reserve stocks are either released until the equilibrium price falls to the FOR release price or reserve stocks are depleted. Similarly, if the initial equilibrium price is above the Commodity Credit Corporation (CCC) release price and reserve stocks are either zero or below their specified minimum, Government stocks are released until the equilibrium price falls to the CCC release price or until such holdings are depleted.

Validation Tests

The ability to provide accurate forecasts depends on the relationships between the different variables included in the model. These relationships fall into one of three categories: definitional, institutional, and behavioral.

Definitional relationships are included to insure that the model will supply a set of estimates that are internally consistent. For example, the model generates estimates of yield per harvested acre and of acreage harvested based on behavioral relationships. To maintain consistency among the estimates, we calculate total production by multiplying acreage harvested by yield per harvested acre.

The institutional relationships include equations used to reflect the operation of farm commodity programs. An example of this type of relationship is the calculation of deficiency payments, which depends on market price, loan rate, target price, and total production eligible for deficiency payments. Once the policy instruments are assigned values and the estimates of market price and program acreage are obtained, deficiency payments can be calculated by use of the formula designated by law.

The two types of relationships discussed above are unique in that the functional relationships among the variables are known, based on logic or rules. This is not the case with behavioral relationships. These relationships are formulated to satisfy economic theory and *a priori* beliefs concerning the interrelationships between variables. There are numerous functional forms which are consistent with these requirements, and the exact functional relationship can never be known with certainty.

The first stage in the model validation process involves selecting an appropriate functional form for each of these relationships. We used ordinary least squares to estimate regression coefficients for many different equation specifications for each relationship.[7] The equations forming the model were selected, based on subjective beliefs (based on actual observed behavior or previous research) regarding parameter signs and magnitudes, "goodness of fit," and the statistical significance of the individual regression coefficients. The size of the model prevents our discussing individual equation characteristics. Instead, we will focus on the dynamic properties of the entire system of equations.

Two simulation methods have been proposed for validating a model consisting of a simultaneous system of equations. The first method is static simulation in which historical values are used for all the lagged endogenous variables each year the model is solved. The second method is dynamic simulation in which the lagged endogenous variables are assigned their historical values only in the initial year for which the model is solved. In all successive years, previous-year model solutions are used for lagged endogenous variables. Thus, the model feeds off itself to generate estimates over the validation period. As FAPSIM was designed primarily for intermediate-term (policy and forecasting) analysis, we chose a dynamic simulation for model validation. All the validation tests reported below are based on the dynamic type of simulation.

A number of statistical measures have been proposed for evaluation of the historical performance of econometric

[7] Annual data for the 1950-79 period were used to estimate the model's coefficients.

models.[8] Each of these statistics provides different information on the model's ability to duplicate historical economic phenomena. Three of these statistics are described below. The first measure is the mean absolute relative error (MARE). It is defined as:

$$\text{MARE} = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{y_t - \hat{y}_t}{y_t} \right| \qquad (11)$$

where:

y_t = the actual value in year t,

$\hat{y}_t$ = the model estimate in year t, and

n = the number of years simulated.

This statistic is an increasing function of the absolute value of the model's prediction error and is independent of the units used to measure y. If the MARE = 0, the model fits the historical data perfectly. Thus, the MARE is bounded from below by zero and increases as the absolute value of the estimation error increases. The main drawback with using this statistic is that it is not bounded from above.

As an alternative, Theil (*20*) proposed the following statistic:

$$U = \frac{\sqrt{\sum_{t=1}^{n} (y_t - \hat{y}_t)^2}}{\sqrt{\sum_{t=1}^{n} y_t^2} + \sqrt{\sum_{t=1}^{n} \hat{y}_t^2}} \qquad (12)$$

It is bounded from above by a value of 1 which will occur when negative proportionality exists between the model's estimates and the historical data or when the model always predicts a zero (nonzero) value for historical values that are nonzero (zero).

Neither of the measures described above is totally adequate for evaluating the model because the model may track the historical values reasonably well in terms of these statistics, but it fails to pick up turning points in the data. This situation gives rise to two types of error: (1) the model may predict a turning point when one does not occur, or (2) the model may fail to predict a turning point when one is present. The relative frequency of these two types of errors is defined as the turning point error (TPE). The closer this statistic is to zero, the better the model.

[8] See (*13*) and (*17*) for indepth discussions on historical validation of econometric models.

The FAPSIM model was validated over the 1966-80 period. Because of the size of the model, we will not present goodness-of-fit measures for each of the 360 endogenous variables. Instead, we present statistical results for those variables regarded as crucial for the purpose of evaluating the performance of the model. These variables include: market price and production for each livestock category, farm-level price and planted acreage for each crop, cash receipts from farm marketings, farm production expenses, net farm income, and the consumer price indexes for food and for all items.

The validation statistics for each variable are reported in table 1. The estimates of livestock and crop prices generally have higher MARE and U statistics than the corresponding production variables. This situation occurs because the final demands for these products are quite inelastic, and any error in the production estimate will cause the equilibrium price to be estimated with even a larger relative error. The TPE for corresponding price and production variables is approximately the same. This similarity is to be expected, because if production is overestimated (underestimated), the equilibrium price will tend to be underestimated (overestimated).

The MARE and Theil's U statistic for the production variables are generally less than 0.07 and 0.05, respectively. A notable exception is the acreage planted to sorghum. The error in this variable is attributable to a large error (53 percent) in the model's estimate of sorghum price in 1972 that caused the sorghum acreage estimates to be off by 41 percent in 1973 and by 39 percent in 1974. If that 2-year period were excluded, the MARE of sorghum acreage would fall to 0.064. In terms of the TPE, the model predicts turning points correctly for each production variable more than 60 percent of the time.

With the exception of barley, the MARE is less than 0.13 and the U statistic is less than 0.09 for each commodity price. As both these statistics indicate that the price estimates exhibit more variability about their actual values than do the corresponding production estimates, we will examine these variables in greater detail.

Figures 1-14 depict the simulated and the historical values for each commodity price. Examination of figures 1-7 reveals that the model appears to track livestock prices reasonably well over the 1966-80 period. The figures suggest that even though the model feeds on itself in a dynamic simulation, errors do not tend to accumulate over the simulation period. In addition, the model performed well for 1980, even though 1980 data were not used in estimation of the model's equations.

Figures 8-14 show the model's estimates of crop year prices over the validation period. The model appears to perform well for all crops. A substantial portion of the prediction

Table 1—Validation statistics, 1966-80

Variable description	MARE	Theil's U	TPE[1]
Pork production	0.039	0.024	0.400
Beef production	.032	.019	.200
Broiler production	.019	.014	.133
Turkey production	.038	.021	.333
Egg production	.022	.013	.400
Milk production	.009	.006	.200
Price of barrows and gilts	.097	.048	.267
Price of slaughter steers	.084	.042	.267
Price of utility cows	.107	.058	.133
Price of broilers	.057	.036	.200
Farm price of turkeys	.088	.046	.400
Farm price of eggs	.095	.052	.400
Farm price of milk	.052	.025	.133
Acreage planted of wheat	.045	.030	.133
Acreage planted of corn	.019	.011	.133
Acreage planted of barley	.061	.037	.200
Acreage planted of sorghum	.109	.085	.200
Acreage planted of oats	.053	.035	.467
Acreage planted of soybeans	.061	.042	.400
Acreage planted of cotton	.074	.047	.400
Farm price of wheat	.118	.062	.333
Farm price of corn	.083	.063	.333
Farm price of barley	.143	.083	.333
Farm price of sorghum	.111	.082	.667
Farm price of oats	.059	.036	.333
Farm price of soybeans	.077	.060	.133
Farm price of cotton	.121	.062	.400
Total cash receipts from farm marketings	.033	.016	.000
Total farm production expenses	.020	.010	.000
Net farm income	.093	.077	.467
Consumer price index, all food	.029	.019	.000
Consumer price index, all items	.005	.003	.000

[1] The number of turning point errors divided by 15, the total number of possible turning point errors.

error for each crop can generally be attributed to a poor model estimate for one particular year. For example, the price of wheat was overestimated by 46 percent in 1972 because of an overestimate of wheat exports and an underestimate of total supply. If that particular year were ignored, the MARE for the price of wheat would fall below 10 percent.

As indicated in table 1, the FAPSIM model predicts receipts from farm marketings, farm production expenses, net farm income, and the consumer prices indexes for food and all items fairly accurately. Both the MARE and Theil's U statistic are relatively low for each of these variables. In addition, the model correctly predicts the turning points in those variables correctly in almost every year.

Overall, the model seems to perform quite well considering its size and the length of the validation period. Of the 32 variables presented in table 1, only 4 were predicted with a mean absolute relative error exceeding 11 percent. Only three variables had turning point errors in more than 6 of the 15 years during the 1966-80 period, which was characterized by unprecedented volatility in the agricultural sector.

Scenario Analysis

Although a model may be capable of predicting past historical events with reasonable accuracy, this does not guarantee that the model will generate reasonable predictions or impacts. To provide an indication of the model's sensitivity and stability, we use the model to analyze two alternative scenarios: (1) a 1-year (1980) increase in corn exports of 500 million bushels and (2) a 1-year (1981) increase in beef imports of 500 million pounds. The impacts associated with both these scenarios are defined relative to a base solution for the 1980-90 period. Thus, for each scenario, the impacts of the initial shock are traced annually through to 1990.

Increase in Corn Exports

Table 2 presents the impacts generated by the model resulting from a 500-million-bushel increase in corn exports in

Figure 1

Price of Barrows and Gilts

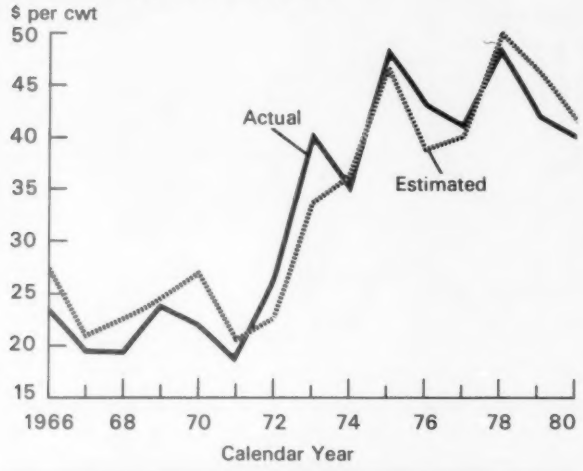


Figure 2

Price of Slaughter Steers

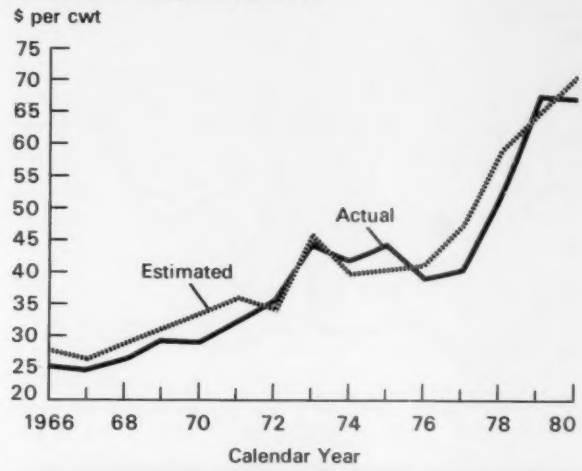


Figure 3

Price of Utility Cows

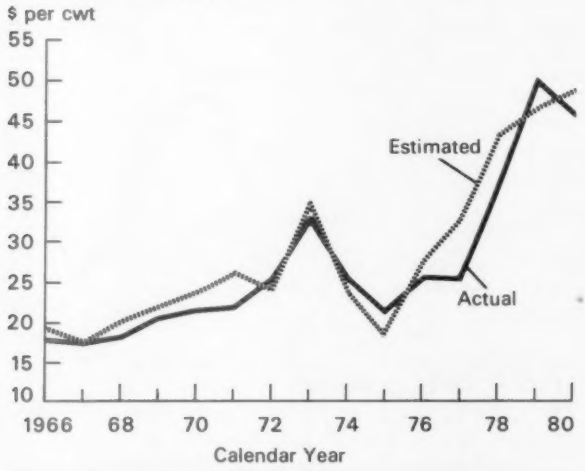
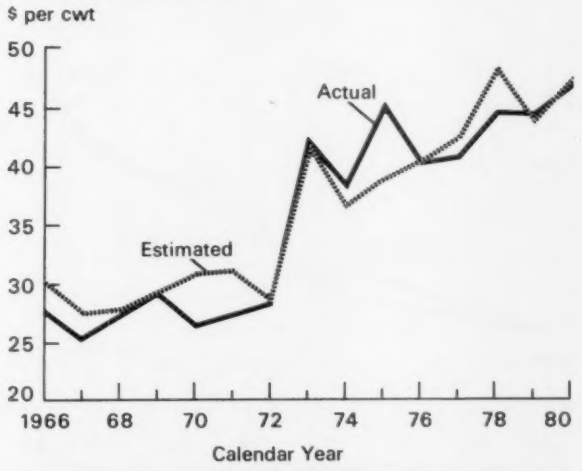


Figure 4

Price of Broilers



crop year 1980. With the exception of cotton, all crop prices are affected immediately by the increase in corn exports. The price of corn increases by $0.75 per bushel in crop year 1980; this is equivalent to a $0.15 per bushel price increase for each 100-million-bushel increase in corn exports. As sorghum, barley, oats, and wheat all substitute for corn as animal feed and human food, their prices also increase. The price of soybeans increases because higher corn prices lead to increased demand for soybean meal as an animal feed. The price of cotton is unaffected by the change in corn exports in the first year because the demand of cotton does not depend on the price of any other crop included in the model.

Because calendar year livestock production is a function of lagged crop year crop prices, initial adjustments in livestock production and prices do not occur until 1981. The increase in corn exports in the 1980 crop year causes 1981 livestock prices to increase. Biological differences between cattle, hog, and poultry production result in differences in shortrun pro-

Figure 5

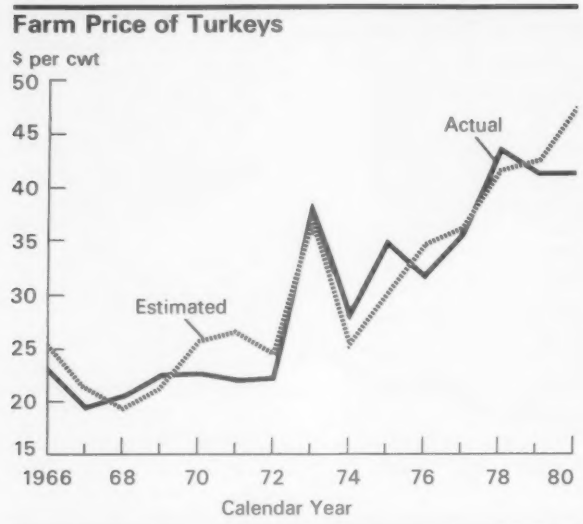


Figure 6

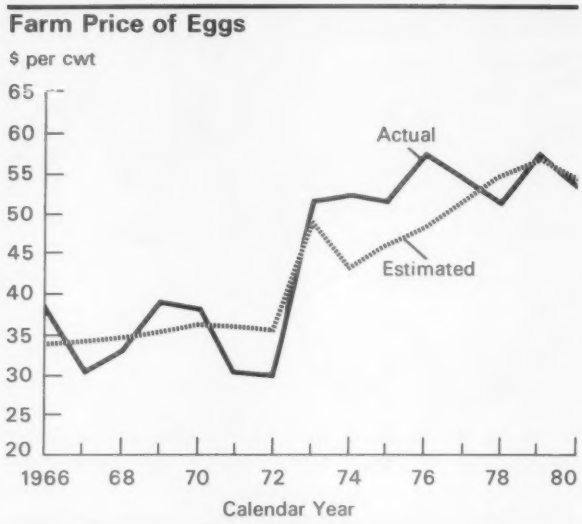


Figure 7

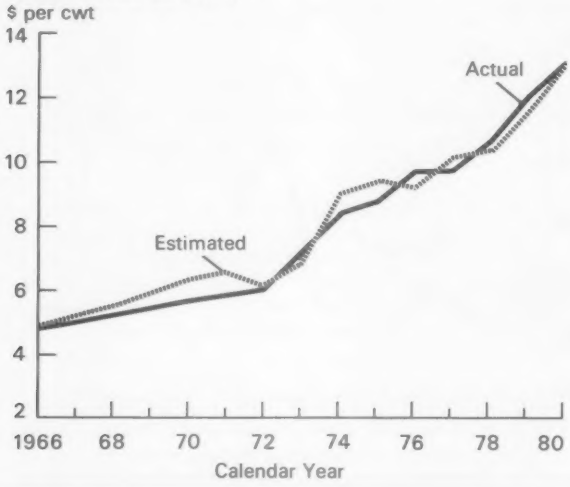
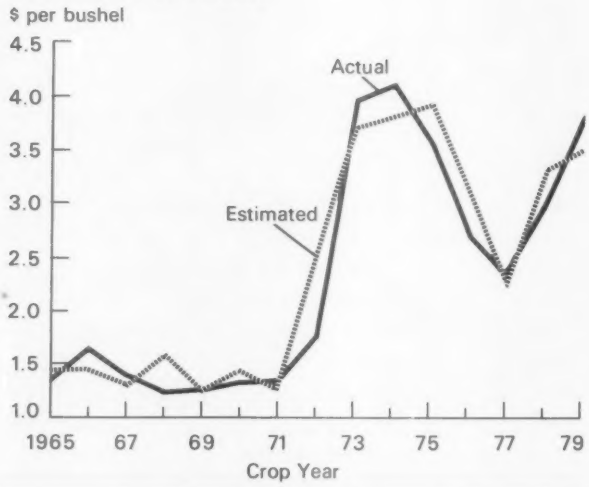


Figure 8



duction and price response. Because chicken and turkey producers can respond quickly (relative to hog and cattle producers) to changes in feed-grain prices by reducing production, the 1981 prices of chickens and turkeys increase relatively more than do the prices of hogs and cattle. The price of turkeys increases relatively more in 1981 than does the price of broilers because the price of chickens increases relative to the price of eggs, thereby reducing egg production but in turn increasing chicken (broiler plus nonbroiler) production. The price of milk remains essentially unaffected by the change in feed costs, because the Government's dairy price-support program tended to insulate milk prices in 1981.

With the exception of pork, production of all livestock commodities declined in 1981 as a direct result of the increase in 1980 crop year exports of corn. Pork production increased even though the price of pork fell relative to the price of corn. In FAPSIM, pork producers respond to a decline in the

Figure 9

Farm Price of Corn

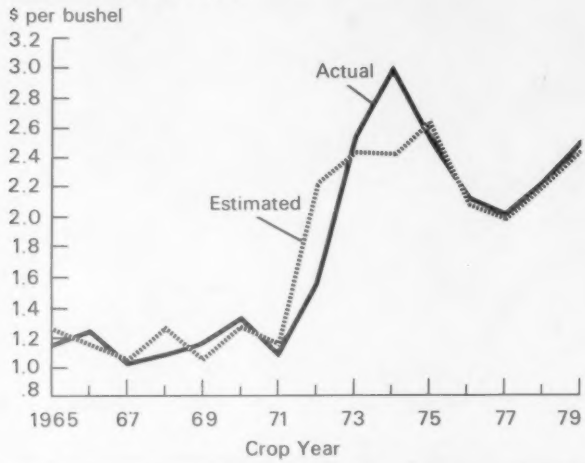


Figure 10

Farm Price of Barley

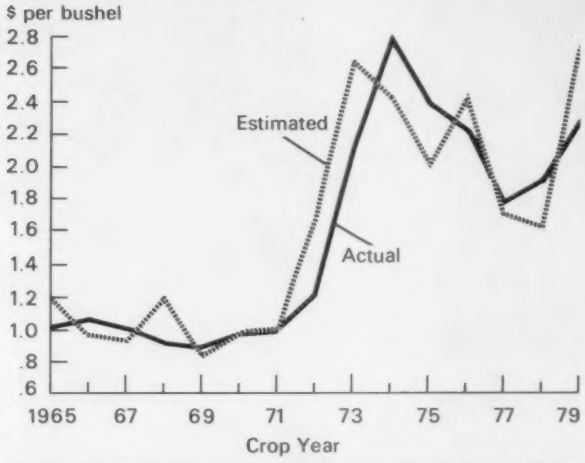


Figure 11

Farm Price of Sorghum

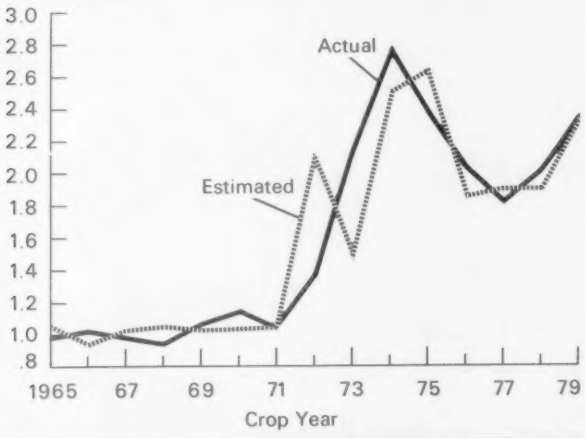
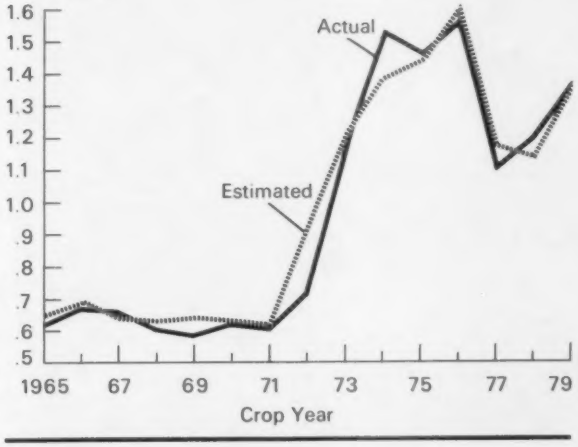


Figure 12

Farm Price of Oats



price of hogs relative to the price of corn by increasing sow slaughter and reducing the number of hogs added to the breeding herd. Both responses increase current year hog production, but also decrease the size of the pig crop. Thus, the model predicts that the increase in hog production resulting from expanding sow slaughter and reducing the number of hogs added to the breeding herd will outweigh the decrease in current year hog marketings resulting from a smaller pig crop. However, succeeding year hog production will decline in response to a smaller inventory of market hogs on farms and a smaller pig crop. Thus, FAPSIM predicts that any large adjustment in hog production will not occur until 1982.

In FAPSIM, acreage planted is a function of the expected return from planting competing crops at planting time. We compute the expected returns using lagged crop year prices. Based on the changes in relative prices in 1980 resulting from the 500-million-bushel increase in 1981 corn exports, acreage of barley, sorghum, wheat, corn, and oats increase.

Figure 13

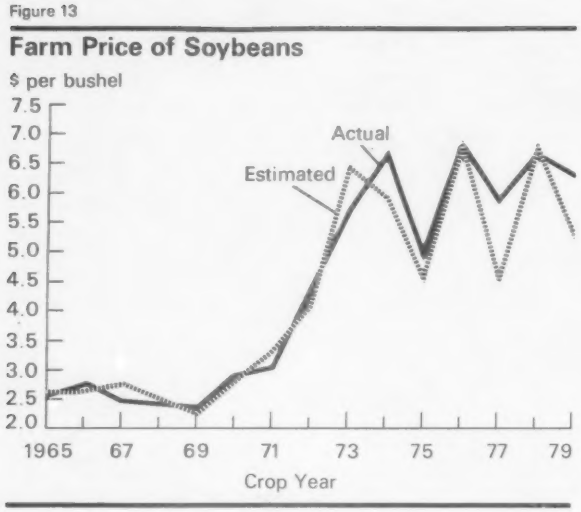


Figure 14

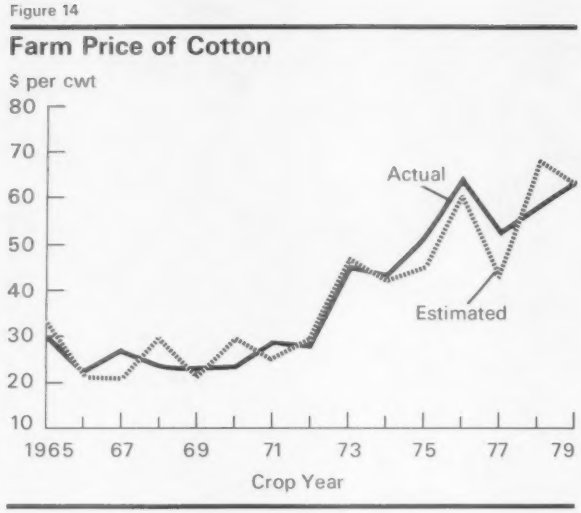


Table 2—Impact of a 500-million-bushel increase in 1980 corn exports

Variable description	Unit	Impact				
		1980	1981	1982	1985	1990
Pork production	Mil. lbs.	0.0	32.6	-345.6	89.2	2.8
Beef production	Mil. lbs.	.0	-237.3	586.2	-695.0	136.9
Broiler production	Mil. lbs.	.0	-64.8	-124.3	81.3	1.0
Turkey production	Mil. lbs.	.0	-14.3	-22.6	16.4	-1.3
Egg production	Mil. doz.	.0	-22.2	-34.8	7.1	-.6
Milk production	Bil. lbs.	.0	-1.3	-.9	-.3	-1.0
Price of barrows and gilts	Dol./cwt	.000	.698	.788	1.162	-.342
Price of slaughter steers	Dol./cwt	.000	1.058	-4.286	4.137	-.476
Price of utility cows	Dol./cwt	.000	.142	-3.254	3.069	-.349
Price of broilers	Dol./cwt	.000	1.305	-.229	.899	-.276
Farm price of turkeys	Dol./cwt	.000	1.389	-.503	1.107	-.260
Farm price of eggs	Dol./doz.	.000	.680	.980	-.003	.029
Farm price of milk	Dol./cwt	.000	.009	.005	.067	.005
Acreage planted of wheat	Mil. acres	.000	1.071	-.425	.050	-.009
Acreage planted of corn	Mil. acres	.000	2.477	-1.237	.096	.092
Acreage planted of barley	Mil. acres	.000	.265	.136	-.005	.004
Acreage planted of sorghum	Mil. acres	.000	2.086	-.981	.000	.096
Acreage planted of oats	Mil. acres	.000	.024	.032	-.014	-.010
Acreage planted of soybeans	Mil. acres	.000	-3.630	2.904	-.173	-.334
Acreage planted of cotton	Mil. acres	.000	-.178	-.413	.051	.159
Farm price of wheat	Dol./bu.	.196	-.127	.014	.014	-.003
Farm price of corn	Dol./bu.	.748	-.218	.094	-.030	.005
Farm price of barley	Dol./bu.	.551	-.185	.006	-.029	.003
Farm price of sorghum	Dol./bu.	.627	-.421	.163	-.048	.001
Farm price of oats	Dol./bu.	.177	-.032	-.001	-.003	-.016
Farm price of soybeans	Dol./bu.	.377	.953	-.527	-.024	.103
Farm price of cotton	Dol./cwt	.000	1.635	2.880	.279	-1.549
Total cash receipts from farm marketings	Bil. dol.	1.504	1.999	-1.968	1.986	-.361
Total farm production expenses	Bil. dol.	1.313	.728	-.607	.493	.139
Net farm income	Bil. dol.	.190	1.271	-.901	1.492	-.499
Consumer price index, all food	1967=1	.000	.010	-.015	.022	-.003
Consumer price index, all items	1967=1	.000	.002	-.003	.004	-.001

However, soybean and cotton acreage declines because the expected returns of competing crops increase by a larger amount. These acreage adjustments in turn cause crop price adjustments in the 1981 crop year, leading to lower wheat and feed-grain prices but to higher soybean and cotton prices.

Total cash receipts and farm production expenses increase in 1981. Higher livestock prices in 1981, coupled with higher crop prices in the 1980 crop year, result in a $2.0-billion increase in 1981 farm cash receipts. Farm production expenses also increase by $0.7 billion in 1981, resulting in an increase in net farm income of $1.3 billion.

As indicated by table 2, beef producers increase beef production in 1982. This reflects increased culling of cows in response to lower returns in 1981. This increase in cow slaughter does not have its maximum impact on production until 1985. After 1985, beef producers begin rebuilding their herds, leading to increased production and lower prices in 1990. These adjustments characterize the dynamic nature of livestock production. The initial increase in corn exports causes the price of corn to increase, signalling producers to reduce production. But it takes time for producers to adjust fully. For the hog producer, this adjustment period is much shorter than for the cattle raiser (but much longer than for broiler producers who can turn around in 3 months). Hog producers may have already made decisions to expand output and have their gilts or sows bred. But the time from breeding until their pigs reach slaughter weight is no more than 10 months. The time from when the cattle producers' heifers are bred until their offspring reach slaughter weight can be about 27 months. Furthermore, if the first offspring are retained to further increase the herd rather than sent to slaughter, it could be about 5-1/2 years from the time the first calf is retained to increase output, until that heifer's offspring reaches slaughter. Because significant lags exist in production adjustment, future livestock production may expand (decline) despite lower (higher) livestock prices.

The dynamic nature of livestock and crop production suggests that any shock to the agricultural sector will have repercussions for many years. But, it is likely that the effect of the shock would dissipate over time. The results presented in table 2 suggest that the impacts on the agricultural sector from an initial shock decline over time. For all variables, with the exception of milk production and the price of cotton, the estimated adjustment in the 1990 estimates are only a fraction of the maximum adjustment occurring during the 1980-90 period.

Decrease in Beef Imports

Table 3 presents the impacts generated by the model resulting from a 500-million-pound decrease in 1981 beef imports. The price of slaughter steers increases by $1.66 per hundredweight or by $0.33 per hundredweight for each 100-million-pound decrease in beef imports. Because beef, pork, chicken, and turkey substitute for beef at the retail level, the prices of these commodities also increase in 1981. The price of milk is virtually unaffected because of the Government dairy price-support program.

Production of beef, broilers, and turkeys increases moderately in 1981. However, pork, egg, and milk production declines slightly in response to higher prices for hogs, cattle, and layers. The maximum response in hog production occurs in 1982, which reflects farmers' response in 1981 to reduce sow slaughter and to add additional hogs to the breeding herd.

Adjustments in livestock prices and production in the 1981 calendar year affect 1980 crop year prices. However, the overall adjustment in crop prices resulting from a 500-million-pound decrease in beef imports appears to be minor. The prices of corn, soybeans, and sorghum increase between 2 and 3 cents per bushel in 1980. The price of sorghum exhibited the largest adjustment in 1980, reflecting the relatively large proportion fed to cattle. The adjustment in crop prices in 1980 in turn influences 1981 acreage planted. Only acreage planted to sorghum appears to respond significantly (-0.10 million acres) in 1981.

Overall, the maximum adjustment in commodity prices resulting from a 1-year decrease in beef imports generally occurs during the initial year of the decline in imports. Maximum impact on crop production occurs 1 year after the adjustment (current crop year) in imports, reflecting the lagged response of crop producers to price. After these initial adjustments, the price and production estimates gradually approach their baseline levels, providing another indication of the model's stability.

Conclusions

We have presented an overview, validation statistics, and dynamic properties of FAPSIM. This model is an annual national econometric model of the U.S. agricultural sector. The model estimates a simultaneous price-quantity equilibrium solution for a set of commodity models developed for beef, dairy, pork, chickens, turkeys, eggs, corn, oats, barley, grain sorghum, wheat, soybeans, and cotton.

The model was validated over the 1966-80 period and was found to perform extremely well given the volatility of the agricultural sector, the length of the validation period, and the size of the model. Of the 32 variables for which validation statistics were computed, only 4 were predicted with a mean absolute relative error exceeding 11 percent. Only three variables had turning point errors in more than 6 of the 15 years of the validation period. In succeeding articles, validation statistics will be presented for the individual submodels contained in FAPSIM. Such statistics will

Table 3—Impact of a 500-million-pound decrease in 1981 beef imports

Variable description	Unit	Impacts				
		1980	1981	1982	1985	1990
Pork production	Mil. lbs.	0.0	-2.5	23.9	-8.6	-0.3
Beef production	Mil. lbs.	.0	34.3	-32.6	59.8	-4.1
Broiler production	Mil. lbs.	.0	7.3	9.5	-3.0	.2
Turkey production	Mil. lbs.	.0	2.3	3.1	-1.0	.2
Egg production	Mil. doz.	.0	-2.5	-4.6	.0	.0
Milk production	Bil. lbs.	.0	-.1	-.2	-.2	-.1
Price of barrows and gilts	Dol./cwt	.000	.995	.047	-.052	.040
Price of slaughter steers	Dol./cwt	.000	1.658	.431	-.254	.059
Price of utility cows	Dol./cwt	.000	1.184	.334	-.189	.043
Price of broilers	Dol./cwt	.000	.841	.133	-.084	.030
Farm price of turkeys	Dol./cwt	.000	.888	.232	-.103	.030
Farm price of eggs	Dol./doz.	.000	.150	.215	-.007	.001
Farm price of milk	Dol./cwt	.000	.001	.001	.038	.000
Acreage planted of wheat	Mil. acres	.000	.037	.111	-.004	.001
Acreage planted of corn	Mil. acres	.000	.024	-.061	.008	.002
Acreage planted of barley	Mil. acres	.000	.009	-.023	.002	.000
Acreage planted of sorghum	Mil. acres	.000	.104	-.029	.010	.001
Acreage planted of oats	Mil. acres	.000	.001	-.008	-.001	-.002
Acreage planted of soybeans	Mil. acres	.000	-.078	.075	-.012	-.007
Acreage planted of cotton	Mil. acres	.000	-.013	-.012	.000	.004
Farm price of wheat	Dol./bu.	.007	.020	-.001	-.001	.000
Farm price of corn	Dol./bu.	.026	.009	.006	.000	.000
Farm price of barley	Dol./bu.	.019	.011	.012	.000	.000
Farm price of sorghum	Dol./bu.	.034	.001	.007	.001	-.001
Farm price of oats	Dol./bu.	.006	.003	.001	.000	-.002
Farm price of soybeans	Dol./bu.	.026	.027	-.015	.003	.002
Farm price of cotton	Dol./cwt	.000	.093	.063	.017	-.037
Total cash receipts from farm marketings	Bil. dol.	.066	1.551	.335	-.093	.017
Total farm production expenses	Bil. dol.	.051	.606	.210	.003	.031
Net farm income	Bil. dol.	.015	.945	.057	-.096	-.014
Consumer price index, all food	1967=1	.000	.010	.002	-.001	.000
Consumer price index, all items	1967=1	.000	.002	.000	.000	.000

provide insight into whether the source of validation error stems from a particular commodity submodel and whether such errors tend to be cumulative across submodels.

We analyzed two shocks to provide information on the model's dynamic properties. The shocks consisted of a 500-million-bushel increase in corn exports and a 500-million-pound decline in beef imports. The initial increase in corn exports caused the price of corn to increase by $0.75 per bushel. Somewhat smaller increases occurred in the price of other feed grains, wheat, and soybeans. The size of the impacts generally declined after the first year for crop variables and after the fifth year for livestock variables for a one-period increase in corn exports. The maximum adjustment resulting from a 500-million-pound decrease in beef imports occurred within 2 years for crop variables and within 1 year for livestock variables. The size of the impacts generated by the model appear reasonable, both in terms of direction of change and magnitude. In addition, the impacts decline after a reasonable adjustment period, suggesting that the FAPSIM model possesses stability.

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Adaptive Expectations, the Exponentially Weighted Forecast, and Optimal Statistical Predictors: A Revisit

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Abstract

Relationships between adaptive expectations, the exponentially weighted moving average, and optimal univariate statistical predictors are reviewed. We show that the behavioral-based adaptive expectations are a subclass of both the exponentially weighted moving average and the (0,1,1) ARIMA model. The applicability of the adaptive expectations model to 25 empirical price and quantity series is investigated. The adaptive expectations behavior and the optimal statistical forecasts are equivalent for 13 series—11 on yields and 2 on prices. Numerous price series, while exhibiting the general form of the adaptive expectations (a (0,1,1) ARIMA process), did not have a coefficient of expectations within the originally hypothesized range. The behavior consistent with the model underlying these price series would be trend extrapolation rather than averaging (averaging the most recent observation and its forecast). Series measured at monthly or quarterly intervals were not adequately modeled by adaptive expectations or as a (0,1,1) ARIMA process.

Keywords

Adaptive expectation, exponentially weighted forecast, optimal statistical predictor, Nerlovian model

A popular expectation model used in agricultural response studies is the adaptive expectations scheme. Its statistical properties and theoretical motivation are given in Nerlove (*15*).[1] The model suggests that period-to-period changes in expectations of economic agents are linearly dependent on the most recent forecast error. Muth notes, "its main *a priori* justification as a forecasting relation has been that it leads to correction of persistent errors, without responding very much to random disturbances" (*12*, p. 299). Although this model seems to have been originally specified on *ad hoc* grounds, it can somewhat coincidentally be represented as an optimal, univariate, statistical predictor of a particular process, which, in fact, is fairly common in many agricultural series.

Our purpose here is twofold: (1) to explicitly review the relationships between the adaptive expectations model, the exponentially weighted forecast, and optimal statistical predictors; and (2) to present some empirical models of such a process. The first part of this article is not a new contribution to the literature; these relationships were presented almost 20 years ago by Muth. They have since appeared in bits and pieces elsewhere, including Box and Jenkins (*5*, p. 107) and Dhrymes (*7*, p. 56). Our justification for the first part of the article is that the exposition in the references cited is not particularly easy. And, although the exposition given here may not be any easier or revealing to some, it may help others. In addition, our empirical results and recommendations will make sense only if a knowledge of these more basic relationships is assumed.

First, we review the relationship between the adaptive expectations model and the exponentially weighted moving average process. Second, we extend the discussion to the class of autoregressive, integrated, moving average (ARIMA) processes. Finally, we present some empirical series which can be adequately represented by such processes. The new contributions to the literature are our empirical results which, along with the accumulating Monte Carlo evidence, we hope will move us to a better understanding of dynamic processes in agriculture.

The Relationship Between Adaptive Expectations and the Exponentially Weighted Moving Average

The adaptive expectations model is discussed in Nerlove. We present it in the following equation:

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[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

$$Y_t^e = Y_{t-1}^e + \beta(Y_{t-1} - Y_{t-1}^e), \quad 0 < \beta \leq 1 \qquad (1)$$

where Y_t is the t^{th} observation on the variable in whose expectation we have an interest; Y_t^e represents its forecast or expectation based on the information through $(t-1)$, and β is a parameter sometimes referred to as the coefficient of expectation.

The model given by equation (1) suggests that economic agents revise their expectations linearly, according to the most recent experience with their prediction accuracy. The model, used by Cagan, Nerlove, and many others, is based on the economic dynamics of Hicks.

Before we demonstrate the conditions under which equation (1) is equivalent to an exponentially weighted moving average of past observations on Y, it is useful to introduce the lag operator L, which is defined by $LY_t = Y_{t-1}$. Thus equation (1) can be rewritten as:

$$(1 - \theta L)Y_t^e = \beta L Y_t, \quad \theta = 1 - \beta \qquad (2)$$

For illustrative purposes, we carry out the algebra in (2) to see that we do indeed have an expression equivalent to (1):

$$\begin{aligned} Y_t^e - \theta Y_{t-1}^e &= \beta Y_{t-1} \\ Y_t^e &= \theta Y_{t-1}^e + \beta Y_{t-1} \\ &= (1-\beta)Y_{t-1}^e + \beta Y_{t-1} \\ &= Y_{t-1}^e + \beta(Y_{t-1} - Y_{t-1}^e) \end{aligned}$$

Solving (2) for Y_t^e in an alternative fashion we have:

$$Y_t^e = \beta(1 - \theta L)^{-1} L Y_t$$

The series, Y_t^e, can be expressed as an exponentially weighted average for $|L| < 1$, if $|\theta| < 1$.[2] That is, for $|\theta| < 1$, we have a product involving the infinite series:

$$\begin{aligned} Y_t^e &= \beta(1 + \theta L + \theta^2 L^2 + \ldots)Y_{t-1} \\ &= \beta(Y_{t-1} + \theta Y_{t-2} + \theta^2 Y_{t-3} + \ldots) \\ &= \beta \sum_{i=1}^{\infty} (1-\beta)^{i-1} Y_{t-i} \end{aligned} \qquad (3)$$

[2] The assignment of an absolute value to the lag operator is an operation described in Box and Jenkins (chap. 3). Dhrymes (chap. 2) rather extensively discusses the algebra of L that permits us to treat it as a complex variable.

The required conditions on $|\theta|$ can be restated in terms of β:

$$\begin{aligned} |1-\beta| < 1 &\rightarrow -1 < (1-\beta) < 1 \\ &\rightarrow -2 < -\beta < 0 \\ &\rightarrow \ 0 < \beta < 2 \end{aligned}$$

This last condition suggests that for Y_t^e to be expressed as an exponentially weighted average, β, the coefficient of expectations, must fall between zero and 2.

A natural question which one might then ask is, "Why did Nerlove restrict β to the unit interval?" To suggest an answer to this question, we might recall the motivating force behind his model. Quoting Nerlove (*15*, p. 52):

> Hicks, it will be remembered, distinguished two limiting cases: an elasticity of zero, implying no effect of a change in current price upon expected future prices; and an elasticity of one implying that if prices were previously expected to remain constant, i.e., were at their long-run equilibrium level, they will now be expected to remain constant at the level of current price. By allowing for a range of elasticities between the two extremes, Hicks implicitly recognized that a particular past price or outcome may have something, but not everything, to do with people's notion of the normal.

Thus, Nerlove was not particularly interested in modeling exponentially weighted expectations *per se*, but rather, was interested in modeling a hypothesized behavior—a behavior which suggests that economic agents change their expectations as a convex combination of the most recently observed actual and expected value of the random variable. For $\beta > 1$, the expectation, Y_t^e will lie outside the interval (Y_{t-1}, Y_{t-1}^e)—a case Nerlove evidently found not very appealing.

The Relationship Between Adaptive Expectations and a Class of Optimal Statistical Predictors

The relationship between the "adaptive expectations" model and an optimal statistical predictor can be obtained from the analysis of two equivalent forms of a general linear statistical model. Following Box and Jenkins, we can write Y_t as equation (4)—a linear function of independent shocks—or as equation (5)—a linear function of past observation on Y_t, plus an added shock.

$$Y_t = \sum_{i=1}^{\infty} \omega_i \epsilon_{t-i} + \epsilon_t; \; E\{\epsilon_t\} = 0 \qquad (4)$$

$$Y_t = \sum_{i=1}^{\infty} \pi_i Y_{t-i} + \epsilon_t; \; E\{\epsilon_t\} = 0 \qquad (5)$$

At a particular time, $t-1$, for known parameters, ω_i and π_i, and for observed shocks, ϵ_{t-i}, $i \geq 1$, we can write the equivalent expectations on equations (4) and (5) as:

$$Y_t^e = \sum_{i=1}^{\infty} \omega i \epsilon_{t-i} \qquad (6)$$

$$Y_t^e = \sum_{j=1}^{\infty} \pi j Y_{t-j} \qquad (7)$$

Lagging equation (4) j periods, substituting each Y_{t-j} into equation (7), and rearranging terms, we have:

$$Y_t^e = \sum_{j=1}^{\infty} \pi j (\epsilon_{t-j} + \sum_{i=1}^{\infty} \omega i \epsilon_{t-i-j}) \qquad (8)$$

Writing out the first few terms of (8), we have:

$$\begin{aligned} Y_t^e = {} & \Pi_1(\epsilon_{t-1} + \omega_1\epsilon_{t-1-1} + \omega_2\epsilon_{t-2-1} + \ldots) \\ & + \Pi_2(\epsilon_{t-2} + \omega_1\epsilon_{t-1-2} + \omega_2\epsilon_{t-2-2} + \ldots) \\ & + \Pi_3(\epsilon_{t-3} + \omega_1\epsilon_{t-1-3} + \omega_2\epsilon_{t-2-3} + \ldots) \\ & + \ldots \end{aligned}$$

Following Muth, we can rearrange terms of this last expression, paying explicit attention to like indexes on ϵ_{t-i}; that is:

$$\begin{aligned} Y_t^e = {} & \Pi_1\epsilon_{t-1} \\ & + \Pi_1\omega_1\epsilon_{t-2} + \Pi_2\epsilon_{t-2} \\ & + \Pi_1\omega_2\epsilon_{t-3} + \Pi_2\omega_1\epsilon_{t-3} + \Pi_3\epsilon_{t-3} \\ & + \ldots \end{aligned}$$

Factoring out ϵ_{t-i}, we have Muth's equation (2.2):

$$Y_t^e = \Pi_1\epsilon_{t-1} + \sum_{i=2}^{\infty} (\Pi_i + \sum_{j=1}^{i-1} \Pi j \omega_{i-j})\epsilon_{t-i} \qquad (9)$$

which is an alternative expression of our equation (6). By comparing coefficients of equations (9) and (6), we have the necessary relation between parameters ω_i, associated with the latent shocks, and Π_i, associated with the history of the process:

$$\begin{aligned} \omega_1 &= \Pi_1 \\ \omega_i &= \Pi_i + \sum_{j=1}^{i-1} \Pi_j \omega_{i-j}, \quad i = 2, 3, \ldots \end{aligned} \qquad (10)$$

We can carry the analysis further by comparing the β weights of equation (3) with the results given in equation (10). This will allow us to characterize the time series for which the exponentially weighted forecast and thereby Nerlove's adaptive expectations model is an optimal statistical predictor. We can substitute:

$$\Pi_j = \beta(1-\beta)^{j-1}, \quad j = 1, 2, \ldots$$

of the exponentially weighted forecast into the equations given by (10). We obtain:

$$\begin{aligned} \omega_1 &= \beta \\ \omega_i &= \beta(1-\beta)^{i-1} + \beta \sum_{j=1}^{i-1} (1-\beta)^{j-1}\omega_{i-j}, \quad i = 2, 3, \ldots \end{aligned}$$

It follows that:

$$\omega_i = \beta, \text{ for all } i \geq 1$$

Thus, we can write (4) in terms of β, our coefficient of expectation:

$$Y_t = \epsilon_t + \beta \sum_{i=1}^{\infty} \epsilon_{t-i} \qquad (11)$$

By lagging equation (11) one period and subtracting, we have:

$$\begin{aligned} Y_t - Y_{t-1} &= \epsilon_t - (1-\beta)\,\epsilon_{t-1} \\ &= \epsilon_t - \theta\epsilon_{t-1} \end{aligned} \qquad (12)$$

which for, $-1 < \theta < 1$ (or $0 < \beta < 2$) is an integrated (differenced) moving average process of order 1. The one-step-ahead forecast, Y_t^e, based on equation (12) is given as:

$$Y_t^e = Y_{t-1} - \theta\hat{\epsilon}_{t-1}$$

where $\hat{\epsilon}_{t-1}$ is given as the one-step-ahead forecast error.

Equation (12) is a special case of the general, univariate, autoregressive integrated moving average (ARIMA) process of order (p,d,q). The models given by equations (4) and (5) can be represented (under rather general conditions) as:

$$\phi(L)(1 - L)^d(Y_t - m) = \theta(L)\epsilon_t$$

where $\phi(L)$ is an autoregressive operator of order p, given as:

$$(1 - \phi_1 L^1 - \phi_2 L^2 - \ldots - \phi pLP)$$

$\theta(L)$ is a moving average operator of order q, given as:

$$(1 - \theta_1 L^1 - \theta_2 L^2 - \ldots - \theta qL^q)$$

Here, as above, L refers to the lag operator, d is an integer indicating the number of differences required to reduce the series Y_t to stationarity, m is the mean of the Y_t series, and ϵ_t is a white noise (random) disturbance.

More explicitly, equation (12) can be written in this form where:

$$\phi(L) = 1, d = 1, \text{ and } \theta(L) = (1 - \theta_1 L^1):$$

$$1(1 - L)^1(Y_t - m) = (1 - \theta_1 L^1)\epsilon_t$$

Carrying out the lag operations, we have:

$$Y_t - m - Y_{t-1} + m = \epsilon_t - \theta\epsilon_{t-1}$$

$$Y_t - Y_{t-1} = \epsilon_t - \theta\epsilon_{t-1}$$

This process is often referred to as a (0,1,1) ARIMA model.

We can identify and fit to time series more general ARIMA processes (different orders of p, d, q) by studying the correlation patterns of the observed series at various lags. This identification process essentially allows the data to suggest which particular process "best" represents the observed data.

The following relations between the autocorrelation and partial autocorrelation functions of the series, Y_t, can be used to identify the more general (p, d, q) ARIMA model:

(a) For a nonstationary process, the autocorrelation function tails off slowly;
(b) For a purely autoregressive process of order p, the autocorrelation function tails off and the partial autocorrelation function has a cutoff after lag p;
(c) For purely moving average process of order q, the autocorrelation function has a cutoff after lag q and the partial autocorrelation function tails off; and
(d) For a mixed autoregressive process of order p and a moving average process of order q, the autocorrelation function is a mixture of exponential and damped sine waves after the first q-p lags, and the partial autocorrelation function is dominated by a mixture of exponential and damped sine waves after the first p-q lags.

Box and Jenkins (*5*) suggest comparing the estimated autocorrelation and partial autocorrelation functions applied to a particular series with the above patterns.

The results we have summarized here suggest that the adaptive expectations model is a subclass of a much larger class of optimal statistical predictors. (For an explicit demonstration of this point in a minimum mean squared error sense, see Box and Jenkins.) We suggest that Nerlove (*15*) was not necessarily interested in modeling optimal statistical predictors, but rather a hypothesized behavior—a behavior which suggests that economic agents form their expectations as a convex combination of their previous expectation and the most recently observed actual value.

Before we move on to the consideration of particular empirical series, we might make a historical note with the purpose of better defining Hicks' role in the theoretical foundations of adaptive expectations. Indeed, if we reread chapter 9 of *Value and Capital*, we note Hicks has a notion of a best or optimum representation of the stochastic process (*9*, p. 126):

> Thus we shall formally assume that people expect particular definite prices, that they have certain price-expectations. But we shall be prepared on occasion to interpret these certain expectations as being those particular figures which best represent the the uncertain expectations of reality.

Continuing in chapter 15, we see that this notion of "best" included values of β, the coefficient of expectations, different from those specified by the adaptive expectations model. For example (*9*, p. 205):

> The elasticity of expectations will be greater than unity, if a change in current prices makes people feel that they can recognize a trend, so that they try to extrapolate; it will be negative if they make the opposite kind of guess, interpreting the change as the culminating point of a fluctuation.

Thus, while Nerlove (*15*) relied on Hicks' work as a basis for adaptive expectations, he chose to model only a portion of Hicks' original hypothesis.

As a final note in this section, we should properly recognize Nerlove's contributions to expectations modeling—a contribution that goes far beyond modeling adaptive expectations. About a decade after introducing us to adaptive expectations, he made a case for modeling optimal statistical

predictors—evidently recognizing the limitations of constraining our representation of expectation to suboptimal descriptions of dynamic economic processes. Recall Nerlove's words written in his seminal work, "Distributed Lags and Unobserved Components in Economic Time Series" (*14*, p. 129):

> One might argue, for example, that the economic agents have a clear conception of what the stochastic mechanism really is; then determine optimal predictors, and, finally use optimal predictors directly as variables in a subsequent statistical analysis . . .

He reiterates this point nearly 5 years later in his more popular paper, "Lags in Economic Behavior" (*17*, p. 230):

> As long as the variables forecast are treated as exogenous in the behavior relationship studied, and if we assume that those economic agents whose behavior we are observing have knowledge of the underlying structure generating the time series to which they react, all manner of distributed-lag relations may be developed. For stationary processes, minimum mean-square-error forecasts and conditional expectations are equivalent. That part of the lag structure arising from expectation formation may be estimated independently of the behavior studied from observations on the variables which are assumed to be forecast.

Finally, in 1979, Nerlove argues (*16*, p. 879):

> If we assume the economic agents, whose behavior we are attempting to describe, are aware of the underlying structure, quasi-rational expectations offer an approximation to fully rational expectations and a far less arbitrary, less ad hoc, approach to expectation formation than the adaptive expectations used in the basic supply response model.

The above arguments support the position that in 1980 adaptive expectations are not particularly relevant—that is, a more general way of doing things exists, and this more general scheme ought to be used, whenever possible. This conclusion would ordinarily be of little importance in that numerous authors have previously made similar appeals (*13*, *14*, *17*); however, a review of the agricultural economics literature suggests that this feeling is not generally held. Indeed, Just (*10*, *11*) Turnovsky (*18*), Askari and Cummings (*1*), and others all wrote well after the above mentioned appeals. And although we recognize that in some cases adaptive expectations may be an appropriate specification, we do not think their distinction as a particular or special type of expectation scheme deserves more than a historical footnote (albeit an illustrious one).

Analysis of Some Empirical Series

Finally, we will explore a few empirical agricultural series. Our motivation for proceeding in this fashion is essentially that given by Nerlove (*17*)—namely, that our analysis of expectations formation may, under fairly general conditions, proceed independent of our analysis of the economic behavior in which we have a more fundamental interest. Thus, in constructing models of agricultural supply response, for example, we can replace the future values of our exogenous variables by their minimum-mean-squared error forecasts. These forecasts can be made independent of all other econometric estimation.

As suggested above, this part of our article is its major contribution to the literature. Even if we had been the first to argue the contents of part 1 (which we were not), the skeptic will remain unconvinced, at least until empirical data have been presented and thoroughly analyzed. It is quite conceivable that the more general stochastic models represented by equations (4) or (5) have no empirical validity beyond a (0,1,1) ARIMA representation, which has a moving average parameter between zero and 1. That is, it may well be that series which we treat as exogenous in our econometric models are in fact properly modeled as adaptive expectations.

We have fitted a first-order moving average process to the first differences of 25 agricultural price and yield series. Table 1 gives the estimated moving average parameters, θ, upper and lower bounds on 95-percent confidence intervals, and diagnostic Q statistics (and their degrees of freedom) for each series.

Recall that for an optimal univariate statistical representation and for adaptive expectations behavior to be equivalent, θ must lie in the interval [0,1]. In addition, the residuals associated with the fitted model must be white noise. That is, adaptive expectations behavior and optimal statistical predictions (and thus Nerlove's quasirational expectations) will be equivalent if our estimated θ value is between zero and 1 and if the unexplained portion associated with the application of such a model is random from time period to time period.

In table 1, notice that series 1, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 19 meet the conditions outlined above. That is, the moving average parameters fall between zero and 1, and the diagnostic Q statistics do not indicate anything but white noise residuals for these series.[3] The remaining series 2, 3, 4, 5, 7, 18, 20, 21, 22, 23, 24, and 25 fail to meet the outlined conditions.

We illustrate the identification of a particular ARIMA model with the autocorrelation and partial autocorrelations on

[3] Q is a diagnostic statistic applied to the residuals from the fitted model. It is described in Box and Jenkins.

Table 1—Estimated (0,1,1) ARIMA processes applied to 25 agricultural series

Series number[1]	θ_L[2]	θ[3]	θ_U[4]	Q[5]	d.f.[6]
1	0.06	0.34	0.62	10.50	14
2	-.97	-.78	-.59	7.57	14
3	-.36	-.05	.26	7.36	14
4	-.65	-.35	-.05	5.17	14
5	-.56	-.26	.05	6.45	14
6	.08	.41	.75	10.20	14
7	.74	93	1.11	11.10	14
8	-.12	.27	.66	7.54	14
9	.36	.64	.92	13.30	14
10	.17	.49	.81	12.40	14
11	.35	.65	.94	11.10	14
12	.12	.46	.81	7.74	14
13	.26	.59	.92	8.42	14
14	.28	.57	.85	15.72	14
15	.29	.56	.84	12.45	14
16	.23	.50	.78	10.10	14
17	.21	.49	.77	11.57	14
18	-.17	.05	.28	62.23*	19
19	-.16	.06	.29	19.11	19
20	.09	.30	.51	47.27*	19
21	.84	.92	1.00	277.80*	19
22	.42	.61	.81	194.10*	19
23	-.27	-.16	-.06	57.68	59
24	-.67	-.58	-.48	335.24*	59
25	-.17	-.08	.02	256.57*	59

[1] Series names are listed in the appendix table.
[2] θ_L refers to the lower bound on a 95-percent confidence interval around the estimated moving average parameter. (Here L is not to be confused with the lag operator.)
[3] θ refers to the estimated moving average parameter associated with the process $(1 - L)Z_t = (1 - \theta L)a_t$ of the particular series.
[4] θ_U refers to the upper bound on a 95-percent confidence interval around the estimated moving average parameter.
[5] Q refers to a diagnostic statistic applied to the estimated residuals from the (0,1,1) process applied to each particular series. An asterisk (*) indicates that the calculated Q statistic is above the critical chi-squared value at the 5-percent level.
[6] d.f. refers to the degrees of freedom associated with the Q statistic reported in the preceding column.

1936-76 Indiana Dubois county corn yields in table 2 (series 15 of table 1). Here note that the estimated autocorrelations on the levels tail off slowly—indicative of possible nonstationary behavior. The autocorrelations on the first differences of the corn yields cut off at lag 1—indicative of nonautoregressive behavior. The partial autocorrelations of the different series, however, seem to tail off, suggesting a moving average behavior. We fit a first-order moving average term to the differenced series.

$$Y_t - Y_{t-1} = -0.56\epsilon_{t-1} + \epsilon_t$$

The residuals associated with this model appear to be nonautocorrelated (table 2). That is, there appears to be no further systematic structure to this series. This is noted by the relatively small autocorrelations associated with various lags of the residual series.

Of the 13 series which do meet the conditions, 11 are yearly yield series; the other 2 are price series. Of the series which do not meet the outlined conditions, series 2, 3, 4, 5, and 23 are adequately fit by the (0,1,1) process; however, the estimated θ values are negative. That is, the diagnostic Q statistics associated with the residuals from a (0,1,1) model fit to these series are acceptable, but the estimated θ values suggest nonadaptive behaviors. These four series are price series. Series 2, 3, 4, and 5 are measured yearly, and series 23 is measured monthly.

The remaining series, which do not meet the conditions for equivalence between adaptive expectations and a (0,1,1) ARIMA process, fail on two accounts; we suspect both underfitting and overfitting. Series 18, 20, 21, 22, 24, and 25 are measured quarterly or monthly. The Q statistics associated with the fitted (0,1,1) model suggest the inappropriateness of the specification. That is, a more complex ARIMA representation is probably required for these series. However, series 7 seems to have been overfitted. The moving average parameter is quite close to the invertibility upper bound (*1*). Elsewhere (*2*) we have suggested that the levels of this series are white noise. Differencing will tend to introduce a nonstationary behavior, and, thus, a (0,1,1) specification is inappropriate. A much simpler process is likely to give a better representation for series 7.

The above results suggest that many series can be adequately modeled as adaptive expectations. In particular, we find many yield series exhibit a stochastic process for which adaptive expectations behavior is optimum. For these series, revision of expectations as a convex combination of the differences

Table 2—Estimated autocorrelations and partial autocorrelations on 1936-76 Dubois County, Ind., corn yields

Auto-correlation		Lags									
		1	2	3	4	5	6	7	8	9	10
Y_t[3]	A[1]	0.73	0.64	0.60	0.49	0.41	0.38	0.40	0.26	0.18	0.05
	P[2]	.73	.22	.17	−.09	−.01	.04	.17	−.25	−.11	−.28
∇Y_t[4]	A[1]	−.49	−.03	.07	−.11	.09	−.19	.28	−.13	.10	−.27
	P[2]	−.49	−.34	−.17	−.24	−.13	−.37	−.05	−.09	.14	−.34
ϵ_t[5]	A[1]	−.20	−.10	−.04	−.15	.00	−.12	.24	−.05	.01	−.22

[1] A refers to estimated autocorrelations at various lags. Approximate standard error is 0.16.
[2] P refers to estimated partial autocorrelations of various lags. Approximate standard error is 0.16.
[3] Y_t refers to the levels of the yield series.
[4] ∇Y_t refers to the first differences of the yield series.
[5] ϵ_t refers to the residuals from the fit first-order moving average representation.

between the previous observation and its forecast makes sense. Drawing an analogy with the macroeconomic literature, we can then say that for these yield series a notion of permanent yield might be a useful concept (similar to Friedman's permanent income). That is, farmers forming optimal expectations on these yield series might view yield as composed of both permanent and transitory components. (For more on the relationship between the (0,1,1) process and the modeling of permanent income, the reader is referred to Nerlove (*14*).) Such behavior might be justified if one notes that specific changes in yield might be viewed as permanent in that they reflect basic changes in technology (new crop varieties, pesticides, and herbicides), whereas other changes might reflect year-to-year variability in weather. It is only the former which farmers will want to incorporate in their future expectations.

Alternatively, we have noted other series are not adequately modeled as adaptive expectations—in particular, most of our price series. The yearly series generally follow a (0,1,1) process; however, the optimal process will tend to extrapolate trends. That is, many of the yearly prices we studied have an elasticity of expectation (β) greater than 1. Thus, instead of finding some middle value between the most recent observation and its forecast, the economic agent who follows an optimal statistical predictor of these series will go outside these upper and lower bounds.

Finally, the series measured quarterly and monthly tend to indicate a more complex univariate ARIMA process. Elsewhere, these series are modeled as seasonal autoregressive and/or moving averages (see *3*, *4*).

Discussion

We have reviewed the relationships between adaptive expectations, the exponentially weighted moving average, and optimal univariate statistical predictors. We have shown that the behavioral-based adaptive expectations are a subclass of both the exponentially weighted moving average and the (0,1,1) ARIMA model. These results have been known heretofore; our review here was a simple prelude to the empirical section of this article.

We have investigated the applicability of the adaptive expectations model to 25 empirical price and quantity series. The adaptive expectations behavior and the optimal statistical forecasts are equivalent for 13 series—11 yield series and 2 price series. We suggest that historical advances in technology and seemingly random weather make this behavior on yield expectations quite reasonable.

The empirical results suggest that 12 series are not appropriately modeled as adaptive expectations. Numerous price series, while exhibiting the general form of the adaptive expectations (a (0,1,1) ARIMA process), did not have a coefficient of expectations within the originally hypothesized range. The behavior consistent with the model underlying these price series would be trend extrapolation rather than averaging (averaging the most recent observation and its forecast).

Finally, series measured at monthly or quarterly intervals were not adequately modeled by adaptive expectations or as a (0,1,1) ARIMA process.

Although adaptive expectations behavior does represent an optimum behavior for many series, it does not for all. Continued use of adaptive expectations in a behavioral model will likely lead to serious specification bias (*13*). Although we have not actually measured economic agents' expectations, until we do so, it seems reasonable that modeling them as suboptimal is not recommended.

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Appendix table—Series number, title, interval measure, and number of observations for 25 agricultural time series

Series number	Title	Interval	Number of observations
1	Tintner's wool prices	Yearly	47
2	California rice prices	Yearly	44
3	California corn prices	Yearly	44
4	California wheat prices	Yearly	44
5	California barley prices	Yearly	44
6	California central valley barley yields	Yearly	32
7	California central coast barley yields	Yearly	32
8	California central valley wheat yields	Yearly	32
9	California central coast wheat yields	Yearly	32
10	California central valley sugar beet yields	Yearly	32
11	California central coast sugar beet yields	Yearly	32
12	Indiana Park County soybean yields	Yearly	33
13	Indiana Tippecanoe County soybean yields	Yearly	33
14	Indiana Hancock County corn yields	Yearly	41
15	Indiana Dubois County corn yields	Yearly	41
16	Indiana Knox County wheat yields	Yearly	41
17	Indiana Ohio County wheat yields	Yearly	41
18	U.S. hog prices	Quarterly	86
19	U.S. cattle prices	Quarterly	86
20	U.S. broiler prices	Quarterly	86
21	U.S. sow farrowings	Quarterly	84
22	U.S. cattle on feed	Quarterly	68
23	U.S. hog prices	Monthly	300
24	Indiana, 1908-32 corn prices	Monthly	300
25	Indiana, 1933-57 corn prices	Monthly	300

Research Review

The Allocation of International Food Aid

By Carol Goodloe*

The food aid program under Public Law (P.L.) 480 has several legislative objectives: (1) to meet humanitarian food needs, (2) to contribute to economic and agricultural development in recipient countries, (3) to develop commercial export markets, and (4) to support U.S. foreign policy goals. However, the law does not indicate priorities among these objectives. Nor does the law require that actual allocations be evaluated with respect to these objectives. The multiple objectives and lack of priorities have led to confusion and criticism over the intent and effect of the program.

Developing countries' requirements for food aid have grown in recent years, while supplies of U.S. grain available for food aid have become increasingly limited. Competition between U.S. commercial and concessional exports may increase. Policymakers need to know the implications of allocating food aid in accordance with the various objectives specified by the law.

This article describes a method for making alternative allocations of food aid that satisfy the various combinations of the four primary objectives of P.L. 480. The method uses different operational definitions of these objectives based on social and economic characteristics of the recipient countries. I examine alternative scenarios and analyze the implications of using different definitions and priorities. I apply this method to the food aid allocations for 1979 to determine which priorities and objectives were most consistent with the actual allocations.

The Food Aid Allocation Method

The method used here allocates food aid according to single or multiple objectives, with each objective defined by one or more socioeconomic indicators (variables) which measure the status of recipient countries with respect to each objective.[1] One alternative defines each objective by a single variable: (1) humanitarian—caloric intake as a percentage of the recommended minimum, (2) economic development—per capita Gross National Product (GNP), (3) market development—grain deficit ratio, and (4) foreign policy—U.S. international economic assistance. The variables for each objective are shown in rows 1-4 of table 1.

Alternatively, the definitions of each objective can incorporate these additional variables:

(5) Child death rate,
(6) Import coverage,
(7) Debt service ratio,
(8) Trade balance ratio,
(9) Ratio of urban to total population,
(10) Average annual growth rate in gross domestic product,
(11) Average annual export growth rate, and
(12) U.S. military assistance.

For example, for the humanitarian objective, the definition of food need is broadened to include variables that measure a country's economic and financial ability to meet that need from its own resources—level of income using per capita GNP (variable 2); level of economic development using the child death rate (variable 5); and the balance-of-payments position using import coverage (variable 6), debt service ratio (variable 7), and trade balance ratio (variable 8). The weights of the variables for each objective sum to 1.0. The multiple variables that define each objective are weighted as shown in rows 5-17 of table 1.

Allocations can be made to achieve single or multiple objectives. Weights are assigned to objectives which sum to 1.0. For example, item 18 in table 1 weights each of the four objectives equally. Thus, allocations can vary depending on both the priority of an objective and its definition.

The variables used are scaled from 0 to 100 to make them comparable. The scaled variables are then multiplied by the appropriate weights. The scaled, weighted variables are used to construct two indexes (not shown in the table) to allocate food aid. One index determines a country's per capita needs. This index is weighted by population to form a second index that determines that country's total needs. I examined different combinations of variables and weights to determine the sensitivity of the method to alternative definitions and priorities.

Analysis of Alternative Allocations

I allocated the value of P.L. 480 exports in 1979—$1.242 billion—among 55 low- and middle-income countries using the above method and examined 23 scenarios. The scenarios were correlated to test for significant differences among both the per capita and total allocations. The primary con-

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[1] See Carol Goodloe, "The Allocation of Food Aid," Staff Report No. AGESS 810707, U.S. Dept. Agr., Econ. Res. Serv., 1981.

Table 1—Weights for objectives and variables

Objective/scenario		Objective weights	Variable weights (see footnotes for each number)											
			1	2	3	4	5	6	7	8	9	10	11	12
Single objective:														
Single variable:														
Humanitarian	1	1.0	1.0	—	—	—	—	—	—	—	—	—	—	—
Economic development	2	1.0	—	1.0	—	—	—	—	—	—	—	—	—	—
Market development	3	1.0	—	—	1.0	—	—	—	—	—	—	—	—	—
Foreign policy	4	1.0	—	—	—	1.0	—	—	—	—	—	—	—	—
Multiple variable:														
Humanitarian	5	1.0	.5	.2	—	—	0.3	—	—	—	—	—	—	—
	6		.4	.1	—	—	.2	0.1	0.1	0.1	—	—	—	—
	7		.4	.2	—	—	—	.2	.2	—	—	—	—	—
Economic development	8	1.0	—	.5	.2	—	.3	—	—	—	—	—	—	—
	9		—	.4	—	—	.2	.1	.1	.2	—	—	—	—
	10		—	.4	.3	—	.1	.1	.1	—	—	—	—	—
	11		—	.25	—	—	—	.25	.25	.25	—	—	—	—
Market development	12	1.0	—	—	.5	—	—	—	—	—	0.3	0.1	0.1	—
	13		—	—	.4	—	—	.1	.1	—	—	.2	.2	—
	14		—	—	.4	—	—	.1	.1	—	.1	.3	—	—
Foreign policy	15	1.0	—	.2	.2	.6	—	—	—	—	—	—	—	—
	16		—	—	—	.5	—	.1	.1	.1	—	—	—	0.2
	17		—	.2	.1	.4	—	—	—	—	—	—	—	.3
Multiple objective:														
Single variable:														
Humanitarian	18	.25	1.0	—	—	—	—	—	—	—	—	—	—	—
	19	.4	1.0	—	—	—	—	—	—	—	—	—	—	—
	20	.1	1.0	—	—	—	—	—	—	—	—	—	—	—
Economic development	18	.25	—	1.0	—	—	—	—	—	—	—	—	—	—
	19	.4	—	1.0	—	—	—	—	—	—	—	—	—	—
	20	.1	—	1.0	—	—	—	—	—	—	—	—	—	—
Market development	18	.25	—	—	1.0	—	—	—	—	—	—	—	—	—
	19	.1	—	—	1.0	—	—	—	—	—	—	—	—	—
	20	.4	—	—	1.0	—	—	—	—	—	—	—	—	—
Foreign policy	18	.25	—	—	—	1.0	—	—	—	—	—	—	—	—
	19	.1	—	—	—	1.0	—	—	—	—	—	—	—	—
	20	.4	—	—	—	1.0	—	—	—	—	—	—	—	—
Multiple variable:														
Humanitarian	21	.25	.5	.2	—	—	.3	—	—	—	—	—	—	—
	22	.1	.5	.2	—	—	.3	—	—	—	—	—	—	—
	23	.4	.5	.5	—	—	.3	—	—	—	—	—	—	—
Economic development	21	.25	—	.5	.2	—	.3	—	—	—	—	—	—	—
	22	.1	—	.5	.2	—	.3	—	—	—	—	—	—	—
	23	.4	—	—	.2	—	.3	—	—	—	—	—	—	—
Market development	21	.25	—	—	.5	—	—	—	—	—	.3	.1	.1	—
	22	.4	—	—	.5	—	—	—	—	—	.3	.1	.1	—
	23	.1	—	—	.5	—	—	—	—	—	.3	.1	.1	—
Foreign policy	21	.25	—	—	—	.5	—	.1	.1	.1	—	—	—	.2
	22	.4	—	—	—	.5	—	.1	.1	.1	—	—	—	.2
	23	.1	—	—	—	.5	—	.1	.1	.1	—	—	—	.2

— = No weight assigned.

1 Calorie intake as a percentage of the recommended minimum, 1976-78.
2 Per capita GNP, 1978.
3 Grain deficit ratio, 1978/79.
4 U.S. international economic assistance, 1979.
5 Child death rate, 1978.
6 Import coverage, 1979.
7 Debt service ratio, 1979.
8 Trade balance ratio, 1979.
9 Ratio of urban population to total population, 1980.
10 Average annual GDP growth rate, 1970-78.
11 Average annual export growth rate, 1970-78.
12 U.S. military assistance, 1979.

sideration was not whether a specific country's allocation was different for each scenario, but whether the overall pattern of the allocations was different.

I first tested the per capita and total allocations for the effect of using alternative priorities for the objectives. The per capita allocations changed significantly depending on the priority assigned to these objectives. For example, per capita allocations under the foreign policy objective were significantly different from allocations under the humanitarian objective. The correlation coefficient (r) was only −0.142. Differences in per capita allocation patterns were greater—the r's were closer to zero—when priority was accorded to a single objective rather than to multiple objectives.

In contrast to the per capita allocations, the total allocations for individual countries varied only slightly among different objectives because the allocation for each country correlated well with its population size. The rank order of the total allocations was nearly identical for each scenario, and the correlation coefficient between most scenarios was near unity. India, with the largest population of the 55 countries, received the largest allocation in all but 1 of the 23 scenarios. Thus, when per capita allocations were of primary importance, the choice of objectives significantly affected the allocations. However, when total allocations were primary, allocations based on population alone would have satisfied all objectives equally well.

I then examined the allocations for the effect of alternative operational definitions for the objectives, using multiple variables to define each objective. The allocations for a specific objective did not change significantly if additional variables and weights were included. For example, the allocations for the three multiple variable scenarios for the humanitarian objective (rows 5, 6, and 7) correlated highly with the single variable scenario (row 1); r equaled 0.898, 0.891, and 0.889. Using a simpler formula with a single variable is sufficient because allocations do not vary significantly with multiple variables.

Comparison with Actual Aid Allocations

Using this method, I compared allocations of Title I and Title II aid for 1979 with the actual country allocations to determine the implied priority assigned to objectives. Under the Title I program, the United States provides long-term concessional loans for the purchase of agricultural commodities. Under the Title II program, the United States donates agricultural commodities for use in special food programs or to help meet emergency needs. The total Title I allocation for 1979 correlated most highly with scenarios 4, 15, 16, 17, 20, and 22 in which foreign policy was the primary objective (table 2). The actual per capita Title I allocation correlated positively and significantly with only three scenarios (4, 16, and 22), again ones in which foreign policy was the primary objective.

This method does not explain the actual Title II allocations. The actual allocation was highly correlated with all but one of the total scenarios and with none of the per capita scenarios. Because of the method's sensitivity to population size, it did not perform as well as when one country was much larger than the others and, therefore, received a preponderant share of the allocation—for example, India in the Title II allocation. In the actual allocations, large countries like India, Indonesia, Bangladesh, and Pakistan received small per capita allocations, whereas in many of the scenarios, these large countries received large per capita allocations because of their relative priority with respect to a specific objective.

Conclusions

We can use a simple weighted-average method to ascertain the extent to which a particular food aid allocation meets the objectives stated in the law and to appraise past decisions in light of these objectives. I applied this method to P.L. 480 exports in 1979 to examine hypothetical allocations based on different priorities and objectives. Per capita allocations varied according to the relative priority of an objective. However, the method's sensitivity to population resulted in total allocations highly correlated with population size. Expanding the definition of the objectives from single to multiple variables did not significantly affect the allocations. Thus, the method was not sensitive to multiple variables and weights.

I used this method to evaluate the implied objectives underlying the P.L. 480 Title I and II allocations in 1979. Foreign policy was identified as the primary objective satisfied by the actual Title I allocations. The method did not identify a primary objective for the actual Title II allocations because the method's sensitivity to population was overwhelmed by the population of India. The lack of correlation with the actual per capita allocations indicated that priority among countries was not assessed on per capita need, but rather on a total country basis with population playing a major role. Large countries received large total allocations, but relatively small per capita allocations. This implies that if the objective is to meet total rather than per capita needs, the simplest rule for allocating food aid is in proportion to population.

Table 2—Comparison of alternative allocation with actual Title I and Title II allocations, 1979

Objective/scenario		Title I		Title II	
		Total	Per capita	Total	Per capita
		Correlation coefficient			
Single objective:					
Single variable:					
Humanitarian	1	0.456	−0.467	0.964	0.157
Economic development	2	.517	−.508	.964	.088
Market development	3	.647	.445	.334	.161
Foreign policy	4	.979	.662	.833	−.047
Multiple variable:					
Humanitarian	5	.491	−.455	.963	.172
	6	.528	−.305	.960	.236
	7	.547	−.264	.957	.171
Economic development	8	.515	−.485	.962	.073
	9	.559	−.242	.960	.265
	10	.535	−.424	.951	.005
	11	.602	.163	.950	.313
Market development	12	.634	.441	.936	.145
	13	.514	.171	.953	.290
	14	.530	.170	.953	.282
Foreign policy	15	.726	.272	.968	−.078
	16	.926	.673	.865	.059
	17	.818	.378	.966	−.038
Multiple objective:					
Single variable:					
All four objectives	18	.608	−.036	.964	.218
Humanitarian-economic development	19	.555	−.311	.965	.194
Market development-foreign policy	20	.691	.366	.961	.206
Multiple variable:					
All four objectives	21	.606	−.112	.962	.254
Market development-foreign policy	22	.758	.646	.955	.204
Humanitarian-economic development	23	.700	.458	.960	.264

Journal of a Tamed Bureaucrat: Nils A. Olsen and the BAE, 1925-1935

Richard Lowitt, ed. Ames: Iowa State University Press, 1980. $16.95, 266 pp.

Reviewed by Kenneth R. Farrell*

Journal of a Tamed Bureaucrat is a pithy, highly personal view of the programs, personalities, and politics of the Bureau of Agricultural Economics (BEA) and the U.S. Department of Agriculture (USDA) during 1925-35, as seen and recorded by Nils A. Olsen, chief of the Bureau for 7 years beginning 1928. An aggressive, egocentric, and protective administrator, Olsen totally committed himself and the Bureau to departmental affairs and to the seething agricultural policy issues of his time—the McNary-Haugen two-price plans, the Federal Farm Board and its market stabilization schemes through cooperatives, and the birth and early operations of the Agricultural Adjustment Administration.

Clearly, the Bureau and the Department were, as Lowitt notes in his introduction to the *Journal*, ". . . an exciting, challenging, and confusing place in which to work" during the 10-year span of Olsen's diary. Personalities such as Louis Bean, Mordecai Ezekiel, Chester Davis, Herbert Hoover, George Peck, O. C. Stine, Jesse Tapp, Rex Tugwell, Henry A. Wallace, and M. L. Wilson all feature prominently in the evolution of farm policy as described by Olsen. The clash of ideas and personalities, the bureaucratic intrigue, and jockeying for position, described in detail and relished by Olsen, provide insight into policy formulation and administration that students of agricultural policy will find stimulating and informative.

In the introduction, Lowitt has very capably provided an overview of agricultural policy issues of the era. This is a useful framework for integrating Olsen's sometimes cryptic notes. But it is Olsen's journal entries which impart the sense of crisis in agriculture of the times, the timid and conservative views of the Hoover administration, and the chaos and quantum changes in policies during the early New Deal. Readers will not find lengthy, technical discussion of the economic rationale undergirding farm programs in the Olsen journal. From the detailed recounting of discussions with Henry A. Wallace on their daily morning walks to USDA to expression of his private, inner mistrust of Tugwell, the journal is a highly personal document. Discussion of policy and departmental administration is cloaked in the recounting of his personal relationships with his colleagues in the Department.

In some respects the issues, policy and administrative, which occupied Olsen are strikingly different from those which occupy comparable bureaucrats in USDA today. There was no Food Stamp Program; regulatory programs were of lesser scope; cooperatives wielded much more power in the Department and in agricultural policy deliberations; commodity surpluses and depressed farm income were chronic, rather than sporadic or cyclical; the Department was singularly and unabashedly the farmers' Department; organization and administration were simpler. (Olsen's position combined the current positions of Assistant Secretary for Economics, Administrator of the former Economics, Statistics, and Cooperatives Service, and substantial parts of the former Science and Education Administration and the Agricultural Marketing Service.)

But, in other respects the issues confronting Olsen strongly resembled those of today. Export expansion was a major policy objective; the creation of the Foreign Agricultural Service over strong objections from Herbert Hoover and the Department of Commerce permeated many of the early entries in Olsen's journal. Land use was a central issue, albeit in the context of a relatively cheap, abundant resource and chronic excess capacity in agriculture. In many ways Olsen's 1929 farm policy prescriptions have a ring relevant even today: production adjustment, revision of land policies, development of foreign markets, promotion of cooperatives, revision of rural credit systems, improvement of transportation systems, tax reduction on farm lands, and strengthening of research and extension.

As one who held administrative posts in the Economic Research Service and its successor agencies for 10 years, I see other parallels in our respective experiences—the sensitivity of policy officials to price forecasting, the issues of balance between "service" and longer run research, sporadic reorganization threats and splintering of the Agency to staff other offices of the Department by what Olsen labeled the "wrecking crew" in the Office of the Secretary, budget reductions, tensions arising from the professionalism of BAE and from the desire of policy officials for ideological commitment to their policies and programs.

Apart from the deterioration of his personal working relationships with Secretary Wallace's immediate staff stemming from differences with Tugwell and bureaucratic "end runs" by members of Olsen's own staff, Olsen's most persistent administrative problem centered on bureaucratic contentiousness, first with the Federal Farm Board and later with the Agricultural Adjustment Administration (AAA). Both entities were concerned with administration of agricultural adjustment programs; each was independent of BAE; and each was

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organized and staffed in part by stripping out functions and personnel from the BAE. Olsen was never able to accept those arrangements. One can surmise that his personal resentment may have obscured his views of the programmatic and policy merits of the Board and the AAA to the extent that his effectiveness as BAE chief was substantially eroded before his resignation in 1935.

Olsen served with three Secretaries during a decade of economic crises and chronic adjustment problems in American agriculture. Then, as now, economic information and analysis were critical to policy formulation and program administration. Olsen well understood that essential fact and made the most of it to establish his own role as well as that of the BAE as a vital source of data, economic research, and outlook information. Although he was deeply immersed in the "political economy" of agriculture and of the Department, his journal reveals a deep appreciation of the importance of professionalism and objectivity in the economic research and statistical functions of the BAE. May it continue to be so in the successor agencies of BAE.

As a "tamed bureaucrat" of more recent vintage, I enjoyed reading and commend to students of agricultural policy, agricultural politics, and agricultural history the *Journal of a Tamed Bureaucrat.*

Imperfect Markets in Agricultural Trade

Alex F. McCalla and Timothy E. Josling, eds. Montclair, N.J.: Allanheld, Osmun and Co., Publishers, Inc., 1981. $29.50, 240 pp.

Reviewed by William E. Kost*

International agricultural markets can best be evaluated in the context of market structure, conduct, and performance. This is the theme of a book that grew out of a 1979 symposium on agricultural trade. The book surveys the current state of research on international agricultural markets and the policies that influence their performance. Two positions are derived from this viewpoint: (1) domestic and international agricultural policy issues are closely related, and (2) the relevant theoretical framework for analysis of international agricultural markets is imperfect competition.

The book consists of an introductory chapter, seven papers, and an excellent 63-page bibliography on international agricultural trade issues.

In "Structural and Market Power Considerations in Imperfect Agricultural Markets," McCalla argues that one cannot understand international agricultural markets without explicitly recognizing their structure. This recognition leads immediately to an analysis of market power, and McCalla concludes that agricultural markets are imperfect. A review of literature reveals that most empirical analysis hinges on assumptions of perfect competition or monopoly. Because these markets seem to be oligopolistic, the models used to date have only limited usefulness. McCalla concludes that any descriptive structural model must include a price formation mechanism that includes explicit recognition of the participants' market power. He suggests that the past emphasis on perfect competition and monopoly models may be based on economists' propensity ". . . to seek deterministic, equilibrium and market clearing solutions" (p. 25), whereas disequilibrium modeling approaches may be a more fruitful direction for analysis.

In "Price Formation in International Agricultural Trade," Sarris and Schmitz argue that various agricultural commodity markets differ in market structure (state trading agencies, private traders, multinational firms, and producer marketing boards) and, therefore, in pricing mechanisms. They suggest that alternative oligopolistic pricing mechanisms exist in international agricultural markets: price leadership, price discrimination, spatial pricing, base point pricing, limit pricing, futures market pricing, and others. They also emphasize the role of market information in price formation and suggest that an analysis of the information flow mechanism can shed some light on the type of market structure that exists and, thus, on the price formation mechanism. They suggest that an industrial organization approach to the study of international agricultural commodity market structures and to the price formation mechanism is warranted (and has been little used to date).

In "Domestic Agricultural Price Policies and Their Interaction through Trade," Josling argues that, in open economies, domestic agricultural policy aimed at domestic supply/demand problems partly determines the structure of the world market. Therefore, since an understanding of the structure of the world market is necessary for analyzing and formulating domestic policy alternatives, the analysis of other countries domestic policies becomes critical. In addition, any realistic attempt to negotiate international agricultural policy must also consider domestic agricultural policies. Any economic analysis of international agricultural markets must carefully and explicitly include both domestic and trade policies.

In "Analysis of Imperfections in International Trade: The Case of Grain Export Cartels," Schmitz and McCalla discuss the issues involved in establishing one class of agricultural market restrictions—a cartel. The review of the state of research on this topic indicates that the results hinge more on empirical issues than on theoretical issues and that the relative importance of the domestic market versus the international market complicates the analysis.

In "Empirical Models of International Trade in Agricultural Commodities," Sarris reviews alternative trade modeling methodologies: export supply/import demand equilibrium and supply/demand equilibrium, simultaneous equation models, spacial price equilibrium models, market share models, and Armingtor.-type models. Sarris concludes that no one type of model can best answer the entire range of policy questions. Most models reviewed do not adequately incorporate the linkage between foreign and domestic agricultural policy nor do they incorporate the oligopolistic nature of the market. Sarris thinks that a promising route to modeling involves looking at the export supply/import demand functions from a decision theoretic viewpoint that treats the functions as representing ". . . active policy rules of governments following domestic objectives" (p. 109). The overall methodological framework still seems to fall under the heading of a microeconomic, general equilibrium, supply/demand model.

In "Policy Issues Relevant to United States Agricultural Trade," Hillman reviews the history of U.S. agricultural domestic and trade policy from the viewpoint of the degree

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of public involvement, the inconsistencies inherent in these policies, and the consequences of not integrating domestic and international policies.

In "International Agricultural Policy Issues in Relation to Research Needs," Josling discusses international agricultural trade policy and the performance of the world food system from the viewpoint of efficiency, stability, and equity. His focus is international agricultural policy as discussed at the 1974 World Food Conference.

The book's underlying thesis is that agricultural commodity markets and agricultural policy can only be understood and evaluated in the context of an open economy and that these markets can only be evaluated in the context of an imperfect competition model.

However, I would argue that the assumption of perfect competition does not underlie a majority of the trade models. Most models have included policy/power type variables in their equations. Often, these equations could more appropriately be labeled reaction functions or decision functions rather than the traditionally defined structural supply/demand functions. The models do, however, retain the mathematical property of being simultaneous equation systems. They assume an equilibrium situation exists. They assume that, at the margin, markets clear. That is, markets clear subject to the constraints imposed by the variables added to the system (the ones you would not find in a perfect competition model). Therefore, some of the non-competitive features of the market have been recognized and modelers have attempted to incorporate these oligopolistic features in their models as constraints on a market clearing solution. The models built to date may not be as bad as this book implies. However, as suggested, other modeling approaches to international agricultural commodity trade analysis (such as game theory) may be more appropriate.

The authors indicate that one approach to modeling the oligopolistic nature of the market may be to follow a disequilibrium modeling approach. If you accept the argument that a disequilibrium approach is better than an equilibrium approach when representing real world agricultural markets, than all models to date are probably deficient. Disequilibrium (as opposed to dynamic) models have been infrequently used by economists at any level of analysis. In this context, does a systems dynamics methodology offer some hope to improving international agricultural commodity market modeling and policy analysis?

This book provides a valuable service. It highlights important points that are not examined carefully enough. Markets are imperfect. Participants do have power. Policy can only be analyzed in the context of an open economy. These concepts must be recognized if researchers are to build relevant models of international agriculture. How that behavior is recognized can vary. Existing models have approached it in several ways; these authors suggest several other ways. Still others exist.

There are minor problems that one could quibble with in each of these articles; however, they do not detract from the underlying theme of the book. Anyone interested in international agricultural trade will find this book one of the better additions to the recent literature.

The Socioeconomic Impact of Resource Development: Methods for Assessment

F. Larry Leistritz and Stephen H. Murdock. Social Impact Assessment Series No. 6. Boulder, Colo.: Westview Press, 1981. $23.75, 285 pp.

Reviewed by Thomas F. Stinson*

The environmental impact statement (EIS) has gained popular acceptance as the way to provide local officials with information about the potential hazards of proposed developments. Although much of the emphasis is on items such as air and water pollution and land use conflicts, each EIS also describes social and economic impacts—including the changes in local government's costs and revenues—that are expected to accompany the new project.

Unfortunately, many of these socioeconomic assessments have been of poor quality. They have been incomplete or inaccurate; local officials relying on them have often been misled. Many policymakers and planners have found little relation between the changes projected in the socioeconomic assessment and those which actually occurred in their community.

While most of the blame for the substandard studies must rest with the agencies and consulting firms who prepared them, there have been some mitigating circumstances. Socioeconomic assessments are a relatively new planning tool, and there are no well established guidelines for individual analysts to follow. Until recently there was no sufficiently well-defined body of literature to which analysts could turn for assistance. Those responsible for estimating impacts of large-scale development in rural areas faced the additional problem of adapting techniques designed to assess impacts in large metropolitan areas so as to take account of the special characteristics of small towns and sparsely populated areas.

Most attempts to improve the quality of this work have been precluded by limits on time and budgets. Assessments are usually completed under such severe time pressure that only incremental improvements in technique have been possible. The transfer of information among researchers is further slowed by the tendency of the work completed to be reported either directly to the contracting agency or in publications not generally accessible. Although advances eventually become known to those conducting impact assessments, they remain almost inaccessible to individuals outside the informal communication network.

Leistritz and Murdock's book helps remedy some of those problems. It brings together and summarizes existing information about techniques for estimating social and economic impacts of development. Equally important, it devotes substantial space to discussing the assumptions behind each technique and the problems in implementing them and to describing what each approach can and cannot be expected to do well.

Such a book is particularly timely as the development of impact analysis appears to have hit a plateau. Large, first-generation computer models have been completed, and most of the easy, incremental modifications have been made. Research now must focus on ways of making major improvements in the accuracy of projections. This volume provides a nice marking point, establishing what is generally known, while making attempts to move on.

The book is not for everyone, however. It is most appropriate for those with some training in regional economics or regional science, but with little experience in preparing socioeconomic impact assessments. Administrators and managers trained in other fields, but with responsibilities for overseeing the preparation of socioeconomic assessments, will also find it useful. Or, the book could be used as a set of companion readings for an introductory course in regional analysis.

Those expecting to find a step-by-step outline describing how to conduct a socioeconomic impact analysis of a particular project will be disappointed. The authors assume the reader has more than a passing familiarity with the tools of regional analysis. They describe analytical techniques such as input-output analysis and gravity models in sufficient detail to provide nontechnicians with an idea of how they work, but not in the detail needed for analysts to use them in a particular assessment or to interpret their findings.

The book is also likely to prove somewhat disappointing to the experienced impact analyst. Although the authors do a good job describing the state of the art in socioeconomic assessment modeling as of 1980, they provide little to stimulate thinking about new approaches to problems. This deficiency is particularly noticeable in the chapter on modeling social impacts, where little guidance is provided about which of the many possible areas for research are likely to prove most fruitful. Similarly disappointing is the lack of new insights on possible methods for improving the dynamic capabilities of regional models.

The book has two major sections. The first covers the types of projections needed in an integrated socioeconomic assessment. Chapters on economic, demographic, public service

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(here meaning local public infrastructure), fiscal, and social impacts are provided. Each chapter discusses the key variables to be estimated, standard ways of estimating them, and problems with the techniques. No actual estimates or ranges of estimates are provided, however; the discussion is entirely conceptual. The second section discusses problems of combining social and economic assessments into a single integrated model, reviews in detail several current computerized models, and offers some thoughts on the use of assessments in the policy process.

In general, the strengths of the book mirror the strengths of existing knowledge. The book is most successful in its early chapters and is less satisfying in the chapters on social impacts and the integration of social and economic impacts, areas where current practices and techniques are considerably less well defined. Disappointment with these chapters really reflects a frustration with the inability of current socio-economic assessments to provide information of this type; the authors only make the ambiguities and failings of current techniques more apparent.

A Conference on Modeling and Evaluating Policy and Institutional Impacts on Farm Firms: Theory, Research, Policy, and Extension Applications

Reviewed by Thomas A. Miller*

How can we better estimate the impact of Government policies on individual farm firms? This question was the focus of a 3-day conference held in Washington, D.C., in November 1981. The conference, sponsored by the Economic Research Service (ERS) and the Farm Foundation, discussed using firm (micro) models to improve our understanding of how producers react to changes in policy, institutional, and economic conditions.

Agricultural policymakers and economists are continuously challenged to provide insights into the effects of alternative programs and policies. Analyses of the costs and benefits and distributional impacts of different policies among farms of different types, tenure, equity, size, and region are a critical part of this process. These analyses depend on microeconomic models of the farm firm to provide an understanding of how the units involved in actual production and adjustment decisions react to alternative policy circumstances.

In spite of the need for microanalyses, resources for micromodeling activities in the profession continue to be limited. The challenge considered by the conference was how to enhance the effectiveness of resources devoted to micromodeling. Specific objectives were the following:

1. To develop and improve understanding of the advantages and limitations of farm growth and adjustment models for analyzing policies and conducting extension activities.

2. To foster current and future professional interactions among economists in the U.S. Department of Agriculture (USDA), universities, and other institutions interested in farm growth and adjustment modeling.

Focusing on these objectives was intended to clarify the usefulness of micro farm firm models in evaluating Government policies and to improve the quality of current and future farm growth and adjustment modeling research.

A broad range of firm modeling topics came under discussion: (1) an overview of farm firm models for evaluation of policy and performance, (2) theoretical considerations in modeling firm growth, (3) methods for linking farm and sectoral performance models, (4) implications of the current policy agenda for modeling farm behavior, (5) representation of institutional and legal considerations in farm firm models, (6) risk management models, (7) simulation models, (8) optimizing models, and (9) use of farm models in extension activities. During these sessions, 18 major papers were presented and 24 discussants were heard. A concluding session summarized accomplishments and provided a forum for evaluating the conference.

During the first session of the conference, John E. Lee, Jr., the Administrator of ERS, described the history and need for micromodeling in policy analysis. From the ERS standpoint, the aggregate models being used by the Agency are deficient in their ability to evaluate policy because farm impacts are not represented. Micromodels are needed to improve understanding of the differential impacts of policy and to improve policy appraisal. Knowledge of individual farm circumstances is important both in the assessment of current conditions and in the estimation of how policy will affect farms of different types, sizes, and regions. Issues concerning the structure of agriculture and the resulting USDA Structure of Agriculture Project underscored this point. Existing models, both in ERS and at land-grant universities, sometimes did a poor job of forecasting the response of firms to alternative policies and were sometimes unable to estimate the distributive impacts of policy.

Lee summarized ERS needs for firm-level analytical capability: (1) to understand likely responses of farm firms in alternative regional, commodity, size, and financial situations to various market conditions and policy provisions in order to understand (but not measure) likely aggregate responses; (2) to understand likely distributive impacts of various policy and market situations; and (3) to use this analysis in conjunction (informally) with macro and econometric models. Using micromodels for these purposes defines a legitimate and important subset of activity for economists in the years ahead—sufficiently important to justify investing in this conference and in improving the realism of behavioral models of farm firms.

Historically, the attention of agricultural economists has cycled from micro to macro and back, with USDA and the land-grant universities currently having quite different focuses. Lee asked for a renewed cooperative effort between ERS and university economists, both in advancing the state of the art in micromodeling and in applying the resulting analytical capability to important economic issues. He made it clear that this effort was not to get ERS back

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into the farm management business, but to allow ERS to pick up a neglected analytical tool that can be used to broaden its capability in policy analysis.

The conference papers can be characterized as a collage of observations, hypotheses, model descriptions, problems, conclusions, and unanswered questions. In total, this collage represents the state of the art in farm firm modeling. The highlights include the following sample:

- The actual behavior of agricultural firms is complex; it can only be understood by micromodels that represent the complex dynamics of economic change. Such models provide both qualitative and quantitative results, and research should focus on understanding the behavior of farm firms, rather than on predicting it.

- Policy analysis requires complementary micro- and macromodels of agriculture, as well as explicit institutional arrangements that allow policymakers access to the results and the understanding gained from modeling activities.

- The concept of an economic firm is greatly complicated by tax and legal form-of-ownership considerations, and such complications must be dealt with in farm firm model building. Inflation, tax rules, the resulting financial considerations, and complex legal entities render the concept of a profit-maximizing farm firm only a crude approximation of the real situation.

- Model builders must incorporate risk into micromodels to understand how risk management and the differential risk-bearing ability of farms affect behavior, survivability, and the long-term structural impact of policy.

- Simulation models of farm firms and households can help researchers understand the complex interaction of tax laws, inflation, credit use, and public policy. Unfortunately, the enormous detail required to represent actual behavior in such models may restrict their use in policy analysis.

- Polyperiodic, goal programming, and Monte Carlo programming models have been used to represent farm response to selected economic parameters.

- Extension applications of farm firm models are increasing with the advent of desk-top computers. Researchers must provide highly flexible and generalized software if farmers are going to make effective use of modeling techniques in problem solving.

Clearly, farm firm modeling advanced substantially in the seventies, with numerous successes. Nevertheless, these advances have illuminated new barriers, theoretical questions, and difficulties that still limit the use of micromodels in evaluations of the impact of policy and institutional changes on farm firms.

The final session of the conference summarized some of the remaining questions. The second conference objective, the hoped-for professional interaction among economists interested in farm modeling, certainly was accomplished, with the potential for mutual benefit.

Regarding the first conference objective, understanding the advantages and limitations of farm firm models, the conference identified as many limitations as advantages. This statement is not intended to be negative. The limitations identified, the issues unresolved, and the questions unanswered provide the foundation for further progress. Therefore, my review concludes with a summary of these issues and questions.

What are the uses of models, and who are the clients? Academic scholarship, firm decisionmaking, and policy analysis sometimes represent competing uses for models that tend to muddle the objectives of model research. Potential funding sources are often alienated by this apparent confusion.

Can multipurpose micromodels serve different clients and evaluate different kinds of policies? What consequences of policy are to be evaluated? Should the model builder ask the policymaker what impacts to evaluate? Who are policymakers—the administration, the Congress, lobbyists, or farm organizations?

How can complementary micro- and macromodels be used in policy analyses? Must the aggregation issue be resolved? What role should case studies play in the political process? How complex should models be?

How can human organizational linkages be established between model builders, extension policy educators, policy analysts, and policymakers? How can we diminish the current gaps between ERS economists and model builders at universities? How can modeling activities be divided, and what clientele could each institution serve? How can the experience gained from model building be used in policy analysis?

The complete conference proceedings will be published in 1982. My intent here is to increase demand for the full report. I believe the proceedings will become a benchmark in the literature of farm firm modeling.

American Journal of Agricultural Economics

Edited by James P. Houck, University of Minnesota

Published by the American Agricultural Economics Association

May 1982

Articles: Deaton,Morgan, and Anschel, "Psychic Costs and Rural-Urban Migration"; Delgado and McIntire, "Oxen Cultivation in the Sahel"; Knapp, "Optimal Grain Carryovers"; Ward, "Asymmetry in Fresh Vegetable Pricing"; Adams, Haynes, Dutrow, Barber, and Vasievich, "Private Investment and Lumber Supply." Notes: Simpson, "Countercyclical Aspects of U.S. Meat Imports"; Knipscheer, Hill, and Dixon, "European Soybean Meal Demand"; Surry and Meilke, "Formula Feed Demand in France"; Fisher, "Rational Expectations in Agricultural Economics"; Helmberger, Weaver, and Haygood, "Rational Expectations, Pricing, and Storage"; Groenewegen and Clayton, "Agricultural Price Supports and Cost of Production." Plus more Notes, Proceedings, and Book Reviews.

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